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CONSERVATION TILLAGE TECHNOLOGY RESEARCH: IMPLICATIONS FOR A SUSTAINABLE AGRICULTURE

HEARING

BEFORE THE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH
AND GENERAL LEGISLATION

OF THE

COMMITTEE ON AGRICULTURE,
NUTRITION, AND FORESTRY
UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

ON

RECENT RESEARCH ON THE "ZERO" OR "NO-TILL" METHODS OF CONSERVATION TILLAGE

MARCH 15, 1989

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CONSERVATION TILLAGE TECHNOLOGY RESEARCH: IMPLICATIONS FOR A SUSTAINABLE AGRICULTURE

WEDNESDAY, MARCH 15, 1989

U.S. SENATE, SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION OF THE COMMITTEE ON AGRICULTURE, NUTRITION, AND FORESTRY,
Washington, DC.

The subcommittee met, pursuant to notice, at 9:20 a.m., in room SR-332, Russell Senate Office Building, Hon. Thomas A. Daschle, Chairman, Hon. Kent Conrad, presiding.

Present or submitting a statement: Senators Daschle, Conrad, and Kerrey.

STATEMENT OF HON. KENT CONRAD, A U.S. SENATOR FROM NORTH DAKOTA

Senator CONRAD [presiding]. We are going to begin. The chairman has been somewhat detained, but he will be with us shortly to formally open the hearing, and he has asked that we proceed. Our problem is we are under a fairly serious time constraint this morning because we have to vacate the room at 11 o'clock, and we have a good deal of information to get through this morning. So we will begin the hearing.

Let me just say I want to thank the new chairman of the subcommittee, Senator Daschle, for allowing us to proceed with this hearing. It had been scheduled when I was chairman in the last Congress, and the focus of our attention today is the whole question of no-till/low-till, and the whole question of soil conservation.

Soil erosion is a major obstacle to a strong, sustainable agricultural base. While soil losses average some 6 tons per acre nationally, certain areas are losing soil at rates as high as 25 to 50 tons per acre every year. In my State of North Dakota, we saw rates like that in the fertile Red River Valley from wind erosion during last summer's drought. Since more than a century is required to produce an inch of topsoil, conservation efforts need to do more than simply maintain the soil that we have.

At current rates of soil erosion, large areas of United States cropland will disappear under the effects of wind and water within another 100 years. Clearly, regeneration of the soil is needed, as well as preservation, if the Nation's agriculture is to remain profitable in the 21st century.

Again, today we are going to address the question of no-till and low-till. I want to welcome Senator Kerrey who is a member of this subcommittee and turn to him for any opening statement.

[The prepared statement of Senator Conrad follows:]

STATEMENT BY

SENATOR KENT CONRAD

ON

CONSERVATION TILLAGE TECHNOLOGY RESEARCH: IMPLICATIONS FOR A SUSTAINABLE AGRICULTURE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH, AND GENERAL LEGISLATION

WEDNESDAY, MARCH 15, 1989

9:00 A.M., Room 332 Russell Senate Office Building

I would like to thank the Chairman, Senator Daschle, for calling this hearing and for allowing me to serve as co-chair with him. This subject is an extension of my interests that developed during my chairmanship of this committee in the last Congress. It gives me a great deal of pleasure to know that the present Chairman shares my enthusiasm for exploring the diversity of solutions available through research for the many problems facing agriculture in America.

During the 100th Congress, I had the pleasure of co-chairing hearings with Senator Wyche Fowler of the Subcommittee on Conservation and Forestry. We examined alternative agricultural systems currently practiced by our farmers and the research and extension efforts of the United States Department of Agriculture and the National Research Council. I gained a broad appreciation of the diversity and the ultimate potential of these efforts. Today, we are going to look at recent research on a relatively new conservation practice available to farmers today. I want to welcome the witnesses for this hearing, and thank them for appearing today.

Soil erosion is a major obstacle to a strong, sustainable agricultural base. While soil losses average six tons per acre nationally, certain areas lose soil at rates as high as 25 to 50 tons per acre every year. In my state of North Dakota, we saw rates like that in the fertile Red River Valley from wind erosion during last summer's drought. Since more than a century is required to produce an inch of soil, conservation efforts need to do more than simply maintain the soil that we have.

At current rates of soil erosion, large areas of United State's cropland will disappear under the effects of wind and water within another hundred years. Clearly, regeneration of the soil is needed, as well as preservation, if the nation's agriculture is to remain profitable in the twenty-first century.

Besides the costs to agricultural productivity, sediment has a profound polluting effect on our surface water. Wildlife habitat is damaged and major dredging expenditures are required to maintain commercial shipping and recreational uses of our waterways. Estimates of these societal costs range from $4 billion to over $17 billion per year.

In 1985, the Highly Erodible Land Conservation Provision of the Food Security Act was enacted into law to begin to deal with these problems. Producers who plant an agricultural commodity on highly erodible land must limit soil erosion to acceptable levels or lose their eligibility for any USDA programs. While this legislation affects only 25 per cent of our nation's agricultural lands, it involves over 80 per cent of our two million farmers.

These national averages are about right for North Dakota. In North Dakota, more than 5.5 million agricultural acres are highly erodible, according to the Soil Conservation Service. This represents nearly 28% of my state's farmlands, and involves nearly 90% of our farmers.

Most SCS approved conservation plans involve methods of contour farming and conservation tillage. However, conservation tillage involves a very diverse group of agricultural practices, and its implementation requires a great deal of modification not only at the regional level, but even at the individual farm level. Research and technical support efforts must recognize this and act accordingly.

Supporting the long-range productivity of our farmlands does not alone guarantee the survival of our farmers. Additional factors include the costs of purchasing and maintaining equipment, fuel, and chemical inputs such as fertilizers and pesticides. Farm policy also has a profound effect on the individual farmer, as the Highly Erodible Land Conservation Provision illustrates.

There are several methods of conservation tillage available to help farmers leave crop residue on the soil surface to prevent erosion. Mulch-tilling, Ridge-tilling, Strip-tilling, No-tilling, and other systems all accomplish this goal, helping to conserve the soil over time. Today we will be examining recent research on the "Zero" or "No-Till" methods of conservation tillage.

Today's witnesses represent every level in the chain needed to take basic research from the experiment station and implement it on the farm. We welcome researchers, technical advisers, and farmers to our hearing, and we'd like to encourage dialogue among you. We look forward to hearing from each of you.

STATEMENT OF HON. J. ROBERT KERREY, A U.S. SENATOR FROM NEBRASKA

Senator **Kerrey**. I do not really have any formal statement, Mr. Chairman, other than to ask who had the foresight to schedule this hearing the day after winds in Nebraska and Kansas and the Dakotas blew away probably a couple million tons of topsoil from our land. We in Nebraska have applied relatively aggressive minimum and no-till techniques. And certainly we need to do much more. There are problems at times when some elements of the farm program itself seem to discourage good conservation practices. We in Nebraska have brought 5 million acres of land under soil conservation plans as a consequence of the conservation compliance requirements of the farm bill. So I strongly support those conservation compliance requirements, but we do see individual instances where conservation and the requirement to participate in the program itself are at odds, and I am going to be very interested in listening to how all of you think we need to continue this effort of getting these conservation practices into the hands of the producers themselves.

Senator **Conrad**. Thank you very much, Senator Kerrey. I want to indicate that in our second panel, we will have unveiled a new method, a new drill, for low-till practice, and there will be a short film that has been done to explain this new concept. It is a very exciting concept, and I hope all of you will have a chance to see the film and the presentation. I think it is a very exciting concept.

With that, I want to welcome our first panel: Duayne Baldwin, president of the Manitoba-North Dakota Zero Tillage Farmers Association from North Dakota; Mr. Ralph E. Grossi, the president of the American Farmland Trust from Washington, DC; Mr. James H. Kinsella, manager of the BASF Agronomic Development Center (ADC), Lexington, Illinois; and Dr. Stephen Marley, the professor of agricultural engineering, the Leopold Center for Sustainable Agriculture at Iowa State University. Welcome to all of you. If you would proceed with your statements and summarize please, that would be very helpful to us in our time constraint. We will go through the whole panel and give you 5 minutes each to summarize your statements. Then have some time for questioning, call the second panel, and your complete written statement will appear in the record as if given.

So with that, Mr. Baldwin, welcome. Very glad that you are here today.

STATEMENT OF DUAYNE L. BALDWIN, PRESIDENT, MANITOBA-NORTH DAKOTA ZERO TILLAGE FARMERS ASSOCIATION, GENESEO, ND

Mr. **Baldwin**. Thank you.

Mr. Chairman, members of the subcommittee, I am Duayne Baldwin, president of the Manitoba-North Dakota Zero Tillage Farmers Association. I appreciate this opportunity to discuss the association views with you on the importance of no-till and minimum-till to soil and water conservation and sustainability.

The association's purpose is to preserve our agricultural soil resource for future generations by promoting a system of crop production which drastically reduces soil erosion and builds up organic matter.

Association members have proven that no-till has the ability to conserve soil and enhance soil productivity. No-till and minimum-till can protect a large majority of the cropland acreage in the Northern Great Plains if research and education efforts by land-grant colleges and the Agricultural Research Service are enhanced.

Chemicals play an important role in the no-till cropping system. Several association members have documented a 20 percent increase in herbicide costs, however, the actual amount of herbicide usage was decreased by 20 percent.

Non-point source pollution from chemicals and fertilizer can be minimized by no-till because of increased water infiltration and reduced soil movement. No-till systems have significantly increased organic matter levels which can affect nutrient availability, soil structure, cation exchange capacity, water infiltration, and water holding capacity. It also affects pesticide persistence.

Crop rotation flexibility through crop-base adjustments is needed within farm cropping systems. Financially, most producers depend on farm programs which require them to maintain crops for which they have a base or bases are allowed.

Rotating crops benefits weed control, disease control, and insect control, thereby reducing the need for pesticide inputs and lowering costs.

Controlling production with reduced plantings by acreage set-asides in farm programs has also contributed to increased erosion and decreased long-term productivity.

Tradition, lack of a conservation ethic, peer pressure, and the lack of information on economic viability from university research has also slowed adoption.

Sustainability and long-term productivity would be enhanced with no-till and minimum-till cropping systems. Bauer and Black, soil scientists, USDA-ARS, Mandan, ND, studied the effect of minimum tillage and conventional tillage on soil properties on farm units in Grant County, North Dakota. The outcome supported the premise that most, if not all, of the difference in organic matter level between tillage systems was due to erosion. In reality, the difference in organic matter level between the tillage systems will widen if the current management is maintained. This is likely to occur for two reasons. First, the opportunity for erosion is much greater under the conventional tillage than the minimum-till. Second, productivity of the conventional tilled fields is already lower, so the amount of residue returned will also be lower than will be returned to the stubble mulched fields, further reducing potential organic matter accumulation. However, productivity of the conventionally tilled soils can be brought to the level of minimum-till with nitrogen fertilizer.

Funding needs to be increased for the USDA-ARS Station at Mandan to do more research on long-term soil conservation and productivity. Water quality should also be addressed in research through the monitoring of pesticide and fertility movement, utilization and degradation.

Ag Research and Extension need increased funding to focus greater efforts in studying and promoting the benefits of no-till and minimum-till and their effect on soil erosion, water quality, and the enhancement of wildlife habitat. The association also believes there is a need to analyze current priorities and to redirect some of the resources to place emphasis on soil and water resource management.

Many farm program benefits have encouraged producers to be poor conservationists. Eligibility has been based on land degrading. Future benefits need to provide added incentives for practicing good conservation.

Senator CONRAD. Thank you very much.

[Material provided by Mr. Baldwin follows:]

No-Till Research Needs

A Committee Report of the Manitoba-North Dakota
Zero Tillage Farmers Association

Synopsis - Statement of Research Justification

We appear to comfortably accumulate 1-2 inches of added water as snow pack that until now has not been turned into a yield increase over conventional tillage.

Technical Data Needs

1. Identification of regional impacts of no-till production on disease and insect infestations.
2. Seed bed environment-machinery evaluations to maximize seedling germination and emergence.
3. Nitrogen release characteristics of no-till crop residues.
4. Development of soil property measurements adequately sensitive to access observable trends under no-till management towards soils that are more "mellow" and "appear" to have improved water intake characteristics.
5. Effect of no-till residues on herbicide degradation.
6. Cereal grain breeding for low volume crop residue production.
7. Identification of compaction parameters affecting growth in no-till production.
8. Deleterious effects of swath row decomposition products on seedling emergence.
9. Evaluation of the probabilities within regional weather zones for conditions favoring winter wheat survival.
10. Assessment of microbial and fungi population dynamics under no-till.
11. Equipment design evaluations for reduced tillage (no-till) seedings in high clay content, high moisture level soils.
12. Calibration of soil sampling - testing procedures for maximized management under no-till production.
13. Assessment of soil chemistry, soil organic matter volume and property change under no-till.
14. Effects of mycrorizia populations on crop phosphate uptake.
15. Earthworm population change dynamics under high residue management production.

Management Data Needs

1. No-till vs. conventional production economics on fixed acreage small, medium, and large sized farms.

2. Studies to maximize yields and minimize costs under no-till with common commodities.

3. No-till production economics as a whole farm enterprise compared with conventional tillage at equal equipment investments.

4. Economic evaluation of winter wheat production risks compared with conventional spring wheat seedings.

5. Crop enterprise no-till management economics.

6. Studies to identify low cost management programs for cheat grass and foxtail barley control.

Production Efficiency Needs

1. Field border management studies to control invading weeds.

2. Grain varieties with straw characteristics that allow nitrogen rates for maximum yields and will stand without lodging or shattering for straight combining.

3. Variety performance evaluations under no-till.

4. Equipment design evaluations for low draft, low cost fertilizer application equipment.

5. Field scale or large plot studies to optimize yield advantages offered with residue management under no-till.

6. A sprayer with 160 A/hour capacity in 18 mph winds.

7. Study to identify components for maximum yields under no-till.

Mark Wyum
Research Committee Chairman

MANITOBA-NORTH DAKOTA
ZERO TILLAGE
FARMER'S ASSOCIATION

TO BECOME A MEMBER . . .

Fill out the following and mail to

Banks H. Sieber
General Manager
Manitoba-North Dakota Zero Tillage
Farmer's Association
1206 Bennett Street
Bottineau, North Dakota
58318

NAME: ______________________

ADDRESS: ______________________

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ZIP OR POSTAL CODE: ______________

☐ Farmer Member $20.00

☐ Associate Member $15.00

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ZERO TILLAGE

— *The Practical Alternative*

MANITOBA-NORTH DAKOTA
ZERO TILLAGE
FARMER'S ASSOCIATION

WHAT IS ZERO TILLAGE?

Zero Tillage (No Till) is a system of crop production involving the planting of a crop directly into untilled standing stubble land with a minimum of soil disturbance and, if necessary, herbicides for weed control.

WHAT DOES IT DO?

- cuts erosion to minimum
- reduces saline soil problems
- decreases power requirements
- reduces moisture loss from tillage and evaporation
- increases infiltration to rain and snow melt
- reduces labor
- maintains wildlife habitat
- saves fuel
- cuts machinery costs

HOW DOES IT WORK?

FALL
- harvest and straw spreading
- weed control
- fall fertilize
- fall seeding

WINTER
- snow trap
- winter wheat protection

SPRING
- fertilize
- seeding
- preemergence spraying

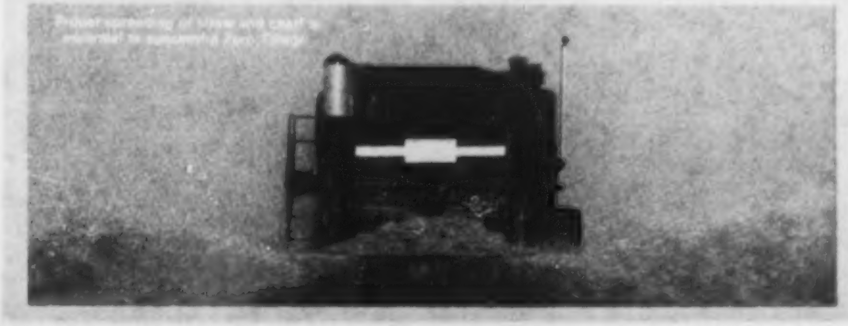
SUMMER
- postemergence spraying

WHERE DOES ZERO TILLAGE WORK?

Soils and climate affect, but do not limit, zero tillage. You will find zero tillage in farming areas all across Canada and the United States.

WHY DOES ZERO TILL WORK?

- Industry and researchers, working with producers, have developed new improved seed drills
- Efficient chaff and straw spreaders for combines are now available
- More effective herbicides and herbicide combinations for weed control
- New methods for applying fertilizer
- A system that catches and stores more moisture for crop use



Proper spreading of straw and chaff is essential to successful Zero Tillage

MANITOBA-NORTH DAKOTA ZERO TILLAGE FARMERS ASSOCIATION

WHO ARE ITS MEMBERS?

Farmer Members
- Any farmer interested in zero tillage

Associate Members
- Others interested in the zero tillage concept including those from business, government or university

WHY AN ASSOCIATION?

- to help the exchange of ideas
- to encourage zero tillage research
- to spread zero tillage information

WHO RUNS IT?

- An elected board of 12 farmers from Manitoba and North Dakota along with six advisors from government and industry plus a general manager.

WHAT DOES THE ASSOCIATION DO?

- Holds annual meeting and workshop
- Encourages and guides research
- Holds tours and demonstrations
- Prints regular newsletter for members
- Produced award winning Zero Till film
- Prepared zero till calendar
- Published zero till production guide
- Publishes Annual Workshop Proceedings
- Offers gate signs to farmer members

HOW IS IT FINANCED?

- Membership fees
- Registration fee at Annual Workshop
- Exhibitors fee at Workshop
- Donations

PROCEEDINGS
OF THE
10TH ANNUAL

Manitoba - North Dakota

ZERO-TILLAGE WORKSHOP

CIVIC AUDITORIUM

JAMESTOWN, NORTH DAKOTA
U.S.A.

Wednesday, Thursday, Friday
January 20-22, 1988

Theme "Zero Tillage -- A Challenging Opportunity"

SPONSORED BY:
THE MANITOBA-NORTH DAKOTA
ZERO-TILLAGE FARMERS ASSOCIATION

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11th Annual
Manitoba-North Dakota

ZERO-TILLAGE WORKSHOP

CONVENTION CENTRE
WINNIPEG, MANITOBA

January 23-25, 1989

Theme "Zero Tillage -- SECOND DECADE"

SPONSORED BY
THE MANITOBA-NORTH DAKOTA
ZERO-TILLAGE FARMERS ASSOCIATION

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"Bakind Soda" Found in Water Lowers Weed Control Success Rate..... 35A

Proper Preparation Essential to AgChemical Sprayer Storage........ 35A

Groundwater Qualtiy Still Rated Good.............................. 36A

Ensure Quality of Stored Herbicides............................... 36A

MANITOBA - NORTH DAKOTA ZERO TILLAGE FARMER'S ASSOCIATION

Sunday, January 22 - HOLIDAY INN DOWNTOWN

7:00-10:00 p.m.	Workshop Registration & Informal Social Evening

Monday, January 23 - WINNIPEG CONVENTION CENTRE

375 York Avenue, Winnipeg, Manitoba R3C 3J3

Chairman	Art Cowan, Hartney, Man.
8:00 a.m.	Workshop Registration*
9:00 a.m.	Preharvest Desiccation with Roundup: Where Will It Fit In Zero Till - Barrie Manikel, Focus On Inputs, Morris
9:30 a.m.	Impact Of Crop Management Systems On Variety Selection - Dr. Elmer Stobbe, University of Manitoba, Wpg.
10:00 a.m.	Profit Pointers For Zero Tillage Oilseed Flax - Luther Berntson, Adams, N. Dak. Soybeans - John Leppert, Sarles, N. Dak. Rapeseed - Robert Stevenson, Oak Lake, Man.
10:45 a.m.	Guest Speaker - Hon. Glen Findlay, Minister of Agriculture
11:00 a.m.	Zero Tilling in Zimbabwe, Africa - Brian Oldreive, Zero Till Grower, Zimbabwe
NOON	LUNCH: Exhibits Open Noon to 5:00 p.m.

AFTERNOON SESSION: PERENNIAL CROPS - A VISION FOR THE FUTURE

CHAIRMAN	Scott Halley, Bisbee, N. Dak.
1:30 p.m.	New Roots For Agriculture: Perennial Polyculture - Dr. Wes Jackson, The Land Institute, Salina, Kansas
2:30 p.m.	Sustainable Agriculture: Low Cost Production For The Prairies - John Gardner, Carrington Research and Extension Center, Carrington, N. Dak.
3:00 p.m.	Crop Rotation - Why Is It So Important? - John Lukach, Langdon Experiment Station, Langdon, N. Dak.
3:30 p.m.	Practical Pointers For Increasing Yield Under Dry Conditions - Ernie French, Williston Experiment Station, Williston, N. Dak.
4:00 p.m.	Annual Association Meeting

EVENING - INFORMAL RAP SESSIONS/NO TILL FOLKLORE - 8:00-10:00 p.m.

I. Weeds & Diseases	Chairman: John Leppert, Sarles, N. Dak. Brian Oldreive, Zero Till Grower, Zimbabwe, Africa Terry Gregoire, NDSU, Devils Lake, N. Dak. Dr. Marcia McMullen, NDSU, Fargo, N. Dak. Dr. Barry Todd, Manitoba Agriculture, Wpg., Man.
II. Soils & Machinery	Chairman: Robert Stevenson, Oak Lake, Man. Owen Beever, Manitoba Agriculture, Brandon, Man. Ernie French, Williston Experiment Station, Williston, N. Dak. John Gardner, Research Center, Carrington, N. Dak. Dr. Wes Jackson, The Land Institute, Salina, Kansas

*Registration Fee of $60.00 US or $70.00 Can. for Zero Till Workshop, Monday only. (Includes Program Proceedings, Newsletter, Gate Sign and 1989 Association Membership). Free Admission to Manitoba Ag Days, Program and Exhibits, Tuesday and Wednesday.

MANITOBA - NORTH DAKOTA ZERO TILLAGE ASSOCIATION AND MANITOBA AG DAYS

Room B - Winnipeg - Tuesday, January 24, 1989

9:30 a.m.	A Comparison Of Weed Control Obtained With Three Spray Systems - Milo Mihajlovich, Dow Chemical, Saskatoon
10:00 a.m.	Effect of Shrouds And Other Wind Reducing Devices On Spray Deposition And Drift - Dr. John Maybank, Saskatchewan Research Council, Saskatoon
10:30 a.m.	Effect of Water Volume and Rate of Efficiency Of Herbicides - Ken Kirkland, Agriculture Canada, Scott
11:00 a.m.	Zero Till In The Red River Valley - A Decade Of Success - Jim McCutcheon, Grower, Homewood
11:30 - 1:30 p.m.	LUNCH BREAK - Tour Exhibits
1:30 p.m.	European Sprayer Technology - What's New In Herbicide And Fertilizer Placement In Europe? - Dr. Fritz Keim, Hoechst Ag, West Germany
2:30 p.m.	Reducing Tillage? Don't Let Canada Thistle Get You Down! - Dr. William Donald, USDA, Fargo
3:00 p.m.	What About This Green Seed Problem In Canola? - John Dean, Manitoba Agriculture, Wpg.

MANITOBA - NORTH DAKOTA ZERO TILLAGE ASSOCIATION

Room C - Winnipeg - Tuesday, January 24, 1989

ZERO TILL FUNDAMENTALS

A PANEL OF EXPERTS OUTSTANDING IN THEIR FIELDS!

9:30 a.m.	Moderator: Terry Gregoire, NDSU, Devils Lake, N. Dak. Joe Breker, Havana, N. Dak. - "How Row Crops Fit Into Zero Till" Bob McNabb, Minnedosa, Man. - "Why Zero Till" Gordon McPhee, Dauphin, Man. - "Zero Till Machinery"

MANITOBA AG DAYS

Room A - Winnipeg - Tuesday, January 24, 1989

MORNING SESSION - MANITOBA HAY DAY

9:30 a.m. Hay Quality - What Does It Mean? - Bill Steeds, Manitoba Agriculture, Wpg
10:00 a.m. The Benefits Of Good Fertility On Hay Quality & Yield - George Bonnefoy, Manitoba Agriculture, Wpg
10:30 a.m. Troublesome Weeds In Hay
Red Bartsia - Rene Caners, Weed Supervisor, Interlake Weed District
Canada Thistle - Alex Holovach, Weed Supervisor, Roblin Weed District
Winter Annuals - Garth Johnson, Weed Supervisor, Wallace Weed District
11:00 a.m. Satellite Monitoring Of Agriculture Crop Land - Hartley Pokrant, Natural Resources, Wpg

AFTERNOON SESSION - GRAIN DAY

1:30 p.m. Grain Handling & Drying Systems Innovative Approaches
Adison Collier, D. Voth & Sons, Manitou
Jim Buhr, Commercial Milling & Cleaning, Portage
2:15 p.m. Aeration Of Hopper Bottom Bins - Darrel Lischynski, Prairie Agriculture Machinery Institute, Humbolt
2:45 p.m. Straight Cutting Grain Crops - Pros & Cons
Grower Panel:
Rick Harcus, Stonewall
Abe Loeppky, Niverville
Garry Wright, Portage

MANITOBA AG DAYS

Room A - Winnipeg - Wednesday, January 25, 1989

MORNING SESSION - FLAX GROWERS WESTERN CANADA

9:30 a.m. Flax Growers Western Canada Report - Garvin Hanley, President Flax Growers, Regina
9:45 a.m. Broadleaf Weed Control In Flax - "What Does The Future Hold?" - Mark Goodwin, Manitoba Agriculture, Wpg
10:15 a.m. Impact Of The 1988 Drought On Agriculture In Manitoba: An Overview - Jim Tokarchuk, Manitoba Agriculture, Wpg
10:45 a.m. Manitoba's Climate - Past, Present & Future - Dr. Tim Ball, University of Wpg., Wpg

AFTERNOON SESSION

1:30 p.m. Green Foxtail Tolerance To Trifluralin - Dr. Ian Morrison, University of Manitoba, Wpg
2:00 p.m. Aquatic Weed Control - Algae & Pond Weeds - Bob Toma, Manitoba Agriculture, Carman
2:30 p.m. Soil Nutrient Levels After The 1988 Drought - John Ewanek & Ken McGill, Manitoba Agriculture, Wpg
3:00 p.m. Chloride Fertilizers - An Update - Dr. Cindy Grant, Agriculture Canada, Brandon

AGRICULTURE OUTLOOK CONFERENCE

General Economy, Market Trents And Price Prospectives For Crops And Livestock

Room B - Everyone Welcome - Winnipeg - Wednesday, January 25

MORNING SESSION

9:25 a.m. Chairman's Opening Remarks
9:30 a.m. General Economy - Dr. Clay Gibson, University of Man., Wpg
10:00 a.m. Farm Income - Dr. Errol Lewis, Manitoba Agriculture, Wpg
10:30 a.m. Question Period
10:45 a.m. Cattle and Hogs - Janet Honey, Manitoba Agriculture, Wpg
11:15 a.m. Question Period With Industry Representatives
11:30 a.m. Cereals and Oilseeds - Carol Nachtigall, Manitoba Agriculture, Wpg
12:00 p.m. Question Period With Industry Representatives
12:15 p.m. Lunch

AFTERNOON SESSION

1:30 p.m. Special Crops - John Dean, Manitoba Agriculture, Wpg
2:00 p.m. Question Period With Industry Representatives
2:15 p.m. Guest Speaker: Hon. Glen Findlay, Minister of Agriculture
3:15 p.m. Chairman's Closing Remarks

Senator **Conrad**. Let me just ask are you a no-till/low-till farmer yourself?

Mr. **Baldwin**. Yes, I am.

Senator **Conrad**. And what has been your experience?

Mr. **Baldwin**. Well, I planted Winter wheat and corn, and I guess I have seen the increase in the organic matter and the earthworms have come back to a greater extent. And it is just exciting to be out and go out in the field and plant in a field that has not been tilled. There is always a good moist seedbed, and you never have the problem with wind erosion. It also holds more snow so you gain probably 1 to 2 inches of precipitation. And the key to gaining that moisture is getting it into the actual production. And I think that is where the problem with conventional tillage lies.

Senator **Conrad**. Have you experienced a reduction in production as a result of going to a low-till or no-till?

Mr. **Baldwin**. No. No, it has not. I guess in regards to the past year, I guess there was similar results because there was such an extreme drought. The difference in the last year with the extreme drought, there was no wind erosion. And that was one of the biggest differences, I guess. That is a big savings when it comes to saving the soil.

Senator **Conrad**. All right. My intention is to go through the whole panel before we get to questions, but I wanted to get that on the record that, in fact, you are someone who practices these methods yourself.

Mr. **Baldwin**. Right.

Senator **Conrad**. And you have had a positive experience.

Next we are going to hear from Ralph Grossi, the director of the American Farmland Trust. Welcome, Ralph.

STATEMENT OF RALPH E. GROSSI, PRESIDENT, THE AMERICAN FARMLAND TRUST, WASHINGTON, DC

Mr. **Grossi**. Thank you, Senator. If you do not mind, I will briefly summarize and speak rather informally about our activities on some of the issues we see related to conservation tillage. First, I would like to give you a brief background of my own experience as a dairy, beef, and small grains farmer from California so that I can shed some of my Washington baggage for the moment. We have a family farm just north of San Francisco, and our own experiences in trying to reduce our input costs include both selling the moldboard plow and going to integrated pest management for fly control as well as a recent effort on our farm to produce hormone-free beef for specialty markets in the San Francisco Bay area.

We are trying to adopt a number of different techniques to reduce our exposure to purchased inputs. As president of the American Farmland Trust, I am charged with directing a nonprofit organization that is deeply interested in soil conservation issues and the policies that affect the way farmers make decisions about the use of their land. To that end, we were extensively involved with the coalition of groups that worked on the 1985 farm bill conservation title and feel quite proud of some of the provisions that were included in that title, including the conservation reserve, sodbuster and compliance provisions.

Two issues related to that title, I think, are appropriate to this hearing today. One is that, as you know, by 1990 all farmers of highly erodible land will have to have a conservation plan and, by 1995, be fully implemented. A major component of those plans turns out to be conservation tillage. Many farmers simply are not going to be able to farm and continue to participate in farm programs without some mode of conservation tillage.

Your hearing is very relevant not only to the 1985 farm bill but to discussions of what might be in the next farm bill in 1990. The second related issue is that which deals with the Conservation Reserve Program. We are currently holding a series of brainstorming workshops around the country, inviting farmers and State agency people and conservationists in to discuss their concerns about farm policy. One of the issues that comes up very high on the agenda is the 11th year of the Conservation Reserve Program (CRP).

Much of this land will come back out of the Reserve. Whether or not that is the right use for that land, we do not know. Nor do we know what the macroeconomic circumstances at that time will be, and whether or not it will be proper to bring that land out of production for an economic reason. But in any case, I think we can agree that much of that CRP land will come back into production. It is crucial for that highly erodible land to have advanced conservation tillage systems available. We *do not* want to see that land plowed. We *do* want to see that land kept in some kind of conserving cover.

Senator **Conrad**. If we can just interrupt a minute, Ralph, and welcome the chairman. He was, as I indicated, unavoidably detained, and we very much appreciate his coming over. How would you like to proceed?

STATEMENT OF HON. THOMAS A. DASCHLE, A U.S. SENATOR FROM SOUTH DAKOTA

Senator **Daschle**. Just as you are. Let me interrupt just for a moment to thank Senator Conrad for taking over. He was and still in my opinion ought to be the chairman of this subcommittee for all the work that he has invested in it in the last couple of years, and I want to commend him. This is a very important hearing to him and to the subcommittee, and I will have a lot more to say about the agenda and the things that we hope to do in this subcommittee at a later meeting. But at this time, I think it is critical that we follow through with the agenda that Senator Conrad had begun last year, and of all the things on the agenda, this is certainly one of the most important. So I appreciate this. I was called to a meeting with the House leadership this morning, and we just got out now, and I apologize profusely for my belatedness and would let you take the hearing back.

Senator **Conrad**. All right. Proceed, Mr. Grossi.

Mr. **Grossi**. I have relayed my concerns related to some of the provisions of the 1985 farm bill and the importance of conservation tillage. Let me relate another concern that I think you have heard probably many times. While we are looking forward to relying heavily on conservation tillage to achieve the soil conservation goals stated in the 1985 farm bill, there is, as you know, a growing concern about the heavy reliance on chemicals for conservation tillage application. There is an argument that there may not be the kind of net gain to society that we had hoped for. While conserving the soil we *may* be polluting the groundwater and killing wildlife at higher rates than had been anticipated due to this heavy reliance on chemicals.

Any new efforts in the conservation tillage area ought to focus then on the next generation of tillage technology, not throwing out the technology because of its impact on ground water, but rather finding ways now to move to the next generation. And I think that is an important direction for our own organization and many others.

We are supporters of the new low-input/sustainable agriculture program at USDA; very disappointed to see that it was not in the President's budget this year. We hope that Congress will restore that funding as it has over the last 2 years. It is important for two reasons. One, it incorporates on-farm research needs; and second, it for the first time builds a structure for two-way transfer of information between farmer and scientist, not just a top-down delivery system but rather a system where farmers can work with scientists in on-farm research projects. We think it is very important. We think it is somewhat of an embarrassment that $4.45 million was appropriated this year for such research.

If Congress saw fit just to take one-tenth of 1 percent of last year's farm subsidies and put it into this program, it would triple the budget of the LISA program next year. I do not think that is too much to ask. And certainly this multidisciplinary research effort complements the conservation tillage issue.

I mentioned our own work on these workshops around the country. In addition to those workshops, we are interviewing 700 farmers in five regions across the country. Those farmers are being interviewed today and over the next month, on their concerns about farm policy, about low-input technologies, about tillage practices.

It is a document that takes an hour and a half to go through with each individual farmer sitting down in their kitchen over a pot of coffee. We hope to bring back much information of farmer concerns of these issues for you in the future, hopefully by mid-May or early June. So I just wanted to let you know that that is in the works.

In these policy workshops we have identified two or three important issues related to this whole concern about cost of inputs. One is that there is a great concern about flexibility at the farm level. In each session that we have held, the concern that the base programs are too constrictive and do not give farmers enough latitude to make decisions based on the marketplace comes up. We hope that can be addressed.

Second, that there is a willingness to adopt new technologies for relatively small incentives, such as cost share incentives that now do not exist.

Finally, in closing I would just like to say that what we see from the conservation and environmental community as well as from the farm community is society placing an increasingly heavy burden on the farmer as steward of the land; expecting more of the individual landowner in terms of water quality, and wildlife habitat sustainability et cetera . The challenge that you have, I believe, as policymakers is to find ways and additional mechanisms by which those important societal goals can mean something to the farmer in his daily decisionmaking process.

While those are worthy goals, they do not spend well at the bank when a farmer has to meet his payments, and that is the difficult challenge we have.

Senator CONRAD. Very good.

Next we will hear from James Kinsella, the manager of the BASF Agronomic Development Center. Welcome.

STATEMENT OF JAMES H. KINSELLA, MANAGER OF THE BASF AGRONOMIC DEVELOPMENT CENTER [ADC] CHEMICALS DIVISION, CENTRAL ILLINOIS NO-TILL FARMER, LEXINGTON, IL

Mr. KINSELLA. Mr. Chairman and members of the subcommittee, I appreciate the opportunity to talk about no-till and its long-term effects. They say a slide or a picture is worth a thousand words. To try to summarize this, I want to show a few slides, and I will go to the projector.

I have been farming my own farm for about 12 years, 100 percent no-till. I grow corn and soybeans in central Illinois. I also manage the BASF No-Till Development Center, where our primary duty is to develop better means of implementing this important practice. I want to share with you a little bit on the long-term effects of no-till because this is something that is least understood at this time, being a new practice. I think no-till is most important to the long-term future of agriculture.

What we see with increasing years of no-till on our farm, as with other farms, is a tremendous improvement in soil structure. The organic matter increases. The soil biology also increases, and that is a very important part of the system, which is often overlooked. The other important part that is overlooked is the tendency for earthworms to come back to our soil. We have two types of earthworms in our fields now. We have the big nightcrawlers which you see at the bottom, and then the little redworms up on the top, and they are both very important to our production system.

Most people felt we killed the earthworms with chemicals and anhydrous ammonia. Actually we kill them with tillage, because they like to keep their food supply on top. They build their houses and each year we come through with tillage tools and destroy them, and they tend to leave. We have controlled them with tillage. Unfortunately, most of the work on earthworm research is not done in the United States. This is work by K.E. Lee in New Zealand, and he shows that it takes about 5 years for land to become infested with earthworms, and that is kind of their normal population explosion. So it is important.

Some work with Dr. Bill Edwards of Coshocton, Ohio. In this slide it shows the effect of the earthworms activity on soil porosity. The bottom axis shows the length of time in no-till (up to 24 years now) and it did show that the percent porosity of the soil went down the first few years of no-tilling. Once the earthworms came back, the porosity went up higher than it was originally, and that is very important to soil water infiltration and soil erosion.

In our fields now we have about 100 of the small holes the size of a pencil lead per square foot, and about 10 of the large holes per square foot. That does not sound like much, but you multiply that out, and that works out to be about 330 miles of big holes per acre and about 800 miles of the small holes per acre, a tremendous infiltration and filtering system that is available in no-till which is not available in a conventional tillage system. If we take a tillage tool through the soil one time, we disrupt that macropore system.

This slide illustrates research work at USDA at Coshocton, Ohio on a 15 percent slope. Dr. Bill Edwards has caught all the water runoff from that field since 1936. Dr. Bill Edwards has summarized two watersheds here. In 10 years of no-till corn he has eight-tenths of an inch of water per acre runoff from a 15 percent slope. Compare that to the conventional where he has lost about 27.9 inches in just 4 years. It is primarily the effect of earthworms and macropore. It has stopped erosion. To me this is the best news in agriculture since the invention of hybrid seed corn, but it has not been publicized. These results should have a tremendous impact on the 1990 farm bill, if we can do that (*stop erosion with no-till*). This is a field next to ours that is in CRP now. And it is only 8 percent slope. If we have determined within USDA facilities we can stop erosion with no-till, why are we paying this farmer about $1,000 per acre for that farm over the next 10 years to stop erosion?

I think if we do go to CRP, we should never ever allow them to plow it again. We can build a no-till farm with CRP. A lot of press articles that came out of the research at Coshocton indicated that all the earthworm holes were going to let the insecticides and chemicals down into the groundwater, and that really has not proven to be the case. Dr. Edwards has found that in putting bottles down 1 foot into the soil where he catches the water and analyzes it for nitrates as well as the chemicals. He has not found that the earthworm holes are a source for a significant amount of chemicals or nitrates to run through.

In fact, the underestimated part of no-till is the increase in the soil biology. You do not hear much about it, but that is what happens as you build up organic matter, improve air and water exchange, and add a lot of soil microbes and earthworms. This adds up to a tremendous filtering system that filters out and neutralizes the chemicals. This is why no-till is to me a very important part of improving our groundwater and not a part of harming it. Also the earthworms go down deep, where they deposit cast material, which is high in organic matter, the food for microbes. Even if some herbicide was to run down there, it would probably be microbially broken down.

A lot of folks are talking about going back to not using any chemicals. I do not think that is feasible in today's agriculture if we are going to be an agricultural power. We are going to need some chemicals. We have to be very wise in how we use them, but I think what is incompatible in today's agriculture is the way we are doing things now. The combination and the interaction of tillage and a lot of chemicals put on the soil, is what is causing the problem. It is causing runoff, and the main thing it is causing is the lack of microbial activity which breaks down about 95 percent of the chemicals put on. This slide illustrates a 2-year-old corn stalk and a 4-year-old cornstalk, in some nice soil that has been tilled heavily in central Illinois. There is not enough microbial activity to break down this organic matter in 4 years, so it is unlikely there is enough to break down any of the herbicides that are put on. I think no-till is very compatible, with clean water but some chemicals are going to be required. We should select those chemicals which will be readily broken down.

But we found that less chemicals are required with no-till. More post-chemicals at lower rates with lower active ingredients per acre, and applied on a lot of residue. We have water infiltration instead of runoff. We are just going to have to watch what ones we use. We want chemicals that are absorbed to the soil with low water solubility, so they will not get in the groundwater, with low persistence and low toxicity. And we have a lot of chemicals in that category right now, used at much lower rates than the traditional soil-applied chemicals we have been using.

What is the problem with water quality? To me 95 percent of the problem is what is running off our fields and not what is running into our fields. Runoff water bypasses the tremendous filter system of a well-maintained soil. There is all kinds of data that shows that no-till is very effective in reducing water runoff, soil loss, as well as chemicals running off our fields and into our lakes and streams. This to me is not sustainable. What we are doing is degenerative agriculture. The combination of tillage and chemistry and everything together. To me no-till is sustainable and regenerative. We are regenerating topsoil. We are using the soil as soil. We have a lot of microbial activity, and this provides a tremendous filtering system for anything that might have a potential to get in the groundwater.

If we can stop this kind of erosion, and we can. We have USDA research that says we can stop this on even a 15 percent slope without buying the ground back from a farmer. And if we can stop this, we can stop what I would consider 95 percent of the water quality problem, which is what is running off and not what is running in.

I will end with this quote from Charles Darwin: "the plow is one of the most ancient and most valuable of man's inventions. But long before he existed on the land, the land was regularly plowed and still continues to be plowed by the earthworms." That was 1881 Charles Darwin.

If Darwin was alive today, I think he would change his statement. I do not believe the plow and earthworms are compatible. They will not coexist. You can plow it either way with steel or with earthworms. We have found that the plowing with earthworms is much more beneficial to the environment and plowing with plows probably tears the environment down. I thank you for your attention.

Senator CONRAD. Thank you very much for that excellent presentation.

[The prepared statement and attachments of Mr. Kinsella follow:]

[EDITOR'S NOTE.—The following submitted material is retained in the subcommittee file: "Conservation Plan and Economic Analysis Compare Your Present System to No-Till" and "No-Till Users Manual Corn-Soybean Rotation-Midwest Edition" Agronomic Development Center BASF Corporation.]

STATEMENT OF JAMES H. KINSELLA, MANAGER OF THE BASF AGRONOMIC DEVELOPMENT CENTER (ADC) AND CENTRAL ILLINOIS NO-TILL FARMER

Mr. Chairman and members of the committee, I appreciate the opportunity to discuss the latest developments in no-till technology. I will also discuss the needs for future research and development, and the effects oflong term no-till farming on soil erosion and water quality.

I would like to speak to you today from two perspectives. First as the Manager of the BASF ADC and second, as a farmer with 520 acres of land in a complete no-till system for over 10 years.

Since my area of research and development focuses primarily on no-till farming systems, I will limit my comments today to no-till farming in the Midwest. I will address the effects of continuous long term no-till farming on 1) soil erosion, 2) the effects on the soil and its productivity, 3) the use of chemicals, 4) water quality, and 5) the water use efficiency in the low rainfall areas.

1) Soil Erosion - No-till or high residue farming systems are without question the most efficient and effective way of controlling soil erosion from both water and wind, short of eliminating row crops. In fact no-till is emerging as the most practical means of getting the highly erodible land (HEL) into compliance by 1995. In talking to the state SCS officials across the Midwest, conservation plans have been submitted on approximately 70% of the HEL farms in the cornbelt. Approximately 3/4 of these plans involve at least some no-till.

The ADC has recently developed a computer program which will compare both the soil loss and the production cost per bushel for a farmer's present system verses a no-till system. Table I illustrates a compliance analysis run on a central Illinois farm. The program calculates all the production cost for both systems. It also allows the farmer to assign a value to his topsoil. The analysis then includes the loss of topsoil, at that value, as a production cost. In this example, the total costs of production (excluding land cost) were as follows: Corn - $1.93/Bu. present system vs $1.40/Bu. in a no-till system, Soybeans - $4.80/Bu. present system vs $3.33/Bu. in a no-till system.

We have run over 500 of these comparisons to date and have not had one conventional or reduced tillage system that has been as efficient as the no-till system, even when not considering the cost of the soil loss. The majority of the cost of production in conventional or reduced tillage systems are in trip cost. With no-till corn or sorghum, the cost of herbicides usually stays the same or is less in no-till. In soybeans, the herbicide cost typically increases from $5.00 to $10.00 from a conventional to a no-till system. This program will presently analyze 6 crops (corn, sorghum, soybeans, wheat, oats, and meadow), in the following Midwestern states: Illinois, Indiana, Iowa Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, Wisconsin.

The program assumes equal yields when switching from the present system to no-till. Our experience has shown that this is attainable and may be conservative on 90% of the HEL farms in the Midwest if they implement no-till in a proven systematic manner. No-till farming is a big change from the system most farmers have learned from childhood, and implementing the system does require considerable education and a commitment to learn. We have also prepared a no-till procedures manual as a guide to implementing a no-till system. One manual is enclosed.

2) The Long Term Effects Of No-Till the Soil and Its Productivity - Since no-till farming is a relatively recent phenomenon and the technology is just now developing to make it dependable, there is little relevant long term research data available. Innovative farmers who were early pioneers in no-till and stuck with the practice are probably the best source of long term information. The USDA/ARS research station at Coshocton, Ohio has various watersheds from which they have caught and measured all the runoff water since 1936. One of these watersheds has been in no-till corn since 1964, which represents the longest running no-till research plot that I am aware of in the U.S.

Dr. Bill Edwards, a researcher at Coshocton, and most others who have no-tilled continuously over 5 years have observed a very significant increase in earthworm activity after tillage stops. Dr. Edwards reports that after 24 years of no-till corn his soil has an average of 15 large night crawler holes per square foot, and numerous small holes made by smaller worms and decaying roots. These pores, that are termed macropores, do not stay intact if deep tillage is accomplished. Thus, macropores are generally unique to continuous no-till fields, non crop land or meadow. These macropores are very important in improving water infiltration into soils and thus reducing runoff and erosion.

Dr. Edwards reports that on his 24 year continuous no-till field a total of .8 of an inch of water per acre has run off of this 15% slope over the last 10 years. An average of 37.5 inches of rain per year fell during that period. In the adjacent conventional tilled field, 27.9 inches of water ran off in only four years before that practice was discontinued.

The most significant agricultural research finding of the last decade, in my opinion, is: CONTINUOUS NO-TILL CAN STOP RUNOFF AND THUS EROSION FROM A 15% SLOPING CLAY LOAM SOIL. This is the USDA/ARS data which has not been publicized and was first released over 3 years ago. I think Congress needs to ask why this data hasn't been publicized, especially with the billions of dollars being spent to put land of much better quality than this into CRP.

The results on my farm and other working no-till farms have been similar to Dr. Edward's results. After about 5 years in no-till, the soil begins to mellow, earthworm populations explode, organic matter increases, soil microbial activity increases, water infiltration improves dramatically, fertility requirements are reduced, and annual weed pressure decreases.

The combination of the above soil improvements plus the improved utilization of the limited rainfall in dry years and in most years in the western cornbelt, make long term no-till systems a more productive and efficient means of farming, and a practical way to comply with the soil erosion guidelines.

3) The Use of Chemicals - It has been widely reported that no-till farming requires significantly more chemicals than conventional farming. This may have been true several years ago, but today with the advances in both equipment and pest control technology this is no longer true. There seems to be little overall difference in disease and insect pressure between crops grown with or without tillage. Some insects and diseases may be slightly more likely in no-till while others are less likely.

Weed control is where differences do occur. Additional chemicals are required to burndown existing vegetation. Higher rates for burndown herbicides are generally required as you move south because of larger weeds at planting and more perennial weeds. The addition of a burndown is generally offset by the change in type of herbicides used for no-till. With significant residue and a build up of organic matter at the surface, the traditional soil applied residual herbicides are not as effective in no-till. The post emergent herbicides are relatively more effective in no-till because they allow the weeds to grow through the residue prior to spraying. Also, the number and severity of weed flushes are generally reduced in no-till. By treating the weeds, instead of the soil, the rate of active ingredients per acre is usually less with post emergent herbicides.

With a well managed weed control program, annual weed pressure generally reduces significantly with time in no-till. The increased population of narrow rowed soybeans commonly used in no-till provide additional crop competition for weed control. In no-till, some perennial weeds may require more herbicide to get them under control initially, but there is less spreading of these weeds once tillage is stopped. Overall, it appears that less chemical active ingredients are required for no-till compared to conventional tillage under today's conditions.

4) Water Quality - Roughly half of the U.S. population drinks well water and half drinks surface water. There is overwhelming evidence that no-till will significantly improve the quality of surface water by reducing the amount of soil leaving the fields. The new data now available indicates that water infiltration will increase significantly with no-till. Thus, reducing runoff of nitrates and of chemicals along with the water and soil.

Some are now speculating that no-till will increase the nitrates and chemicals found in groundwater because of this extra infiltration. This certainly has not been proven and in fact most preliminary data now shows the opposite. Most chemicals are broken down at least in part by microbical degradation. A continuous no-till field becomes very microbically active with time, thus, significantly reducing the chance for these materials to get into the groundwater.

It has also been widely speculated that the earth worm holes in no-till will provide a direct route to the groundwater. Preliminary data from Dr. Edwards indicates this is not the case. Most nutrients and chemicals adhere to the soil particles or are held in the soil capillary water. The water going down the earthworm holes has little contact with either the soil particles or the soil capillary water. The earthworms line their holes with cast material which is high in organic matter and nutrients, both of which encourage microbical activity.

The soil is a tremendously effective filter if it is not abused with excessive tillage. This filter will effectively break down and neutralize most of the chemicals we are using today if we don't overload the system. If we select chemicals which will be neutralized by the soil, applied only when needed, at the correct rates, mix, store, and transport safely, no-till can be an effective means of maintaining a safe supply of both ground and surface water.

With the new technology being developed in fertilizer testing and injecting systems, no-till could provide a significant improvement in the quality of both our surface and ground water. Additional research and new technology is still needed in the area of water quality.

5) Water Use Efficiency in Low Rain Areas - With the insulating effect of the surface residue and mulch, and the improved infiltration with time, no-till offers

a significant improvement in production efficiency in the areas of low rainfall in the Western cornbelt. It also has the potential to improve water use efficiency in irrigated production.

We have really come full circle in agriculture production. We have come back to the way our forefathers farmed. We have spent over 150 years in tearing down our soils with tillage. Now, we have the technology to produce crops abundantly without tillage and to begin building our soils back rather than slowly destroying them.

The main problem we have in turning our agriculture system around is with tradition. We have farmed so long with tillage, it is difficult to change, but we must. We need a major educational effort in order to make this transition. We also need to improve on existing technology to reduce the problems and make farming without tillage more reliable and efficient. I recommend the following research receive high priority from USDA:

- Earthworm growth, development, and effects on the soil in no-till.
- Long term effect of no-till on the soil and environment.
- Revise the USLE to give no-till credit for carryover residue and for improved water infiltration.
- Design new concept planters specifically for no-till.
- Determine the cause for slow early growth of no-till corn and find solutions.
- Determine the cause of allelopathy and develop solutions.
- Fertility rates and placement requirements specifically for no-till.
- Obtain clear registration for 2,4-D as a burndown ahead of no-till soybeans in the Midwest.

(Attached material follows:)

TABLE I

CONSERVATION PLANNING WORKSHEET

Compare Present System to No-Till

Name BRIAN DOYLE Address R.R. #1

City LEXINGTON State IL Zip Code 61753 Phone

County McLean ASCS Farm # 3021 Tract # 2 Field # 1

Crop and Soil Information for Above Farm, Tract and Field

Avg. Crop Acres: Corn 72 Soybeans 77 Sorghum ____ Wheat ____ Oats ____ Meadow ____

Obtain from County SCS: Soil Type LAROSE SILT LOAM Avg. Slope 6 % Length 210 Ft.

Existing Conservation Practices	YES	or	NO
Contour Cropping	☐		☑
Contour Strip Cropping	☐		☑
Cover Crop	☐		☑
Terraces - Spacing ____ ft	☐		☑

Crop Rotation Used *(Check One)*

☐ C-C	☐ B-B
☑ C-B	☐ C-C-O-M
☐ C-C-B	☐ C-O-M
☐ C-C-B-O	☐ C-B-W-M
☐ C-B-W	☐ C-C-B-W-M
☐ C-C-C-W	☐ Other ____

Crop Code:
C = Corn or Sorghum
B = Soybeans
W = Wheat
O = Oats
M = Meadow

PROGRAM WILL ONLY ACCEPT ABOVE CROPS

Information for Economic Analysis

Crop - (Limited to 3) Enter Crop Code →	C	B	
Yield (5 year avg.) Bu/Ac. →	138	46	
Input Cost - $/Acre Present System	ENTER DOLLARS PER ACRE		
Seed	21.15	16.40	
Fertilizer	43.40	14.00	
Herbicide	22.26	17.10	
Insecticide			
Miscellaneous	16.00	7.50	
Interest on above inputs	11.00	6.00	
Field Operations - Present System ..	ENTER NO. OF TRIPS		
Spraying:			
Broadcast	1		
Banding		1	
With Tillage	1	1	
Fertilizing:			
Broadcast	1	1	
Anhydrous (knifed in)	1		
Liquid (knifed in)			
Tillage:			
Disc (tandem		1	
Disc (offset)			
Chisel	1		
Moldboard		1	
V-Ripper			
Shred Stalks			
Field Cultivate	2	2	
Finishing Tool			
Cultimulch			
Tiller (PTO)			
Planting and Cultivation			
Plant	1	1	
Plant/No-till			
Plant/Ridge			
Drill			
Drill/No-till			
Rotary Hoe	1	1	
Cultivate/Row	1	2	
Cultivate/Ridge			

Set-A-Side:

CROP	ACRES
Legume	7
Small Grain	
Other ____	

Required Estimates

Value of Your Topsoil: $ 4.00 /Ton

If Left Blank Program Enters $5.00/Ton

Estimate Your No-Till Herbicide Cost

Circle estimated cost for each crop → *Or*

CROP	LOW	($/ACRE) MED	HIGH	ENTER YOUR ESTIMATE
Corn	13	⑲	25	$
Soybeans	18	30	42	$ 25.00
Sorghum	10	15	20	$
Wheat	0	5	10	$
Oats	0	1.5	3	$

Has this tract of field been designated HEL ?
☑ YES ☐ NO

If YES, has a conservation plan been filed with SCS ?
☐ YES ☑ NO

MAIL COMPLETED FORM TO:

BASF CORPORATION
5420 WEST SOUTHERN AVE.
SUITE 103
INDIANAPOLIS, IN 46241

```
BRIAN DOYLE                          ECONOMIC ANALYSIS                              03-13-1989
ASCS FARM#: 3021
TRACT#: 2     FIELD#: 1

< - - - - - - - Present System - - - - - - - -  >  < - - - - - - - No-Till System - - - - - - - - >

YIELDS:                                            YIELDS:

  Corn    138   Sorghum 0      Soybeans 46           Corn    138   Sorghum 0      Soybeans 46
  Oats     0    Wheat   0                            Oats     0    Wheat   0

INPUT COSTS:                                       INPUT COSTS:
                             $/acre                                               $/acre
                    Corn    Soybeans                                     Corn    Soybeans

  Seed              21.15    16.40    0.00           Seed                23.26    21.81    0.00
  Fertilizer        43.40    14.00    0.00           Fertilizer          43.40    14.00    0.00
  Herbicide         22.25    17.10    0.00           Herbicide           19.00    25.00    0.00
  Insecticide        0.00     0.00    0.00           Insecticide          0.00     0.00    0.00
  Misc              16.00     7.50    0.00           Misc                16.00     7.50    0.00
  Interest          11.00     6.00    0.00           Interest            11.00     6.00    0.00
    * Subtotal *   113.80    61.00    0.00             * Subtotal *     112.67    74.31    0.00

TRIP COSTS:                                        TRIP COSTS:
                     $ acre / # trips                                     $ acre / # trips
                    Corn    Soybeans                                     Corn    Soybeans
   (Spraying)                                         (Spraying)
  Broadcast         3.35/1   0.00/0   0.00/0         Broadcast           6.70/2  10.05/3   0.00/0
  Banding           0.00/0   4.50/1   0.00/0
  With Tillage      1.55/1   1.55/1   0.00/0
    * Subtotal *    4.90/2   6.05/2   0.00/0           * Subtotal *      6.70/2  10.05/3   0.00/0

   (Fertilizing)                                      (Fertilizing)
  Broadcast         2.89/1   2.89/1   0.00/0         Broadcast           2.89/1   2.89/1   0.00/0
  Knifed Anhydrous  5.32/1   0.00/0   0.00/0         Knifed Anhydrous    5.32/1   0.00/0   0.00/0
    * Subtotal *    8.21/2   2.89/1   0.00/0           * Subtotal *      8.21/2   2.89/1   0.00/0

   (Tillage & Planting)                               (Tillage & Planting)
  Disc/tandem       0.00/0   6.10/1   0.00/0         Plant/No-till      10.67/1   0.00/0   0.00/0
  Chisel            9.68/1   0.00/0   0.00/0         Drill/No-till       0.00/0  13.50/1   0.00/0
  Moldboard         0.00/0  12.05/1   0.00/0
  Field Cultiv.    10.20/2  10.20/2   0.00/0
  Plant             8.67/1   8.67/1   0.00/0
  Rotary Hoe        3.22/1   3.22/1   0.00/0
  Cultiv./Row       4.90/1   9.80/2   0.00/0
    * Subtotal *   36.67/6  50.04/8   0.00/0           * Subtotal *     10.67/1  13.50/1   0.00/0

SUMMARY:                                           SUMMARY:
                        $/acre/year                                         $/acre/year

  Input Costs        113.80    61.00      0.00       Input Costs        112.67    74.31     0.00
  Trip Costs          49.78    58.98      0.00       Trip Cost           25.58    26.44     0.00
  Harvest Costs       26.00    24.00      0.00       Harvest Costs       26.00    24.00     0.00
  Total Var Cost/Ac  189.58   143.98      0.00       Total Var Cost/Ac  164.24   124.75     0.00
  Total Var Cost/Bu    1.37     3.13      0.00       Total Var Cost/Bu    1.19     2.71     0.00

  Ave Soil Loss (t/ac) 19.2   19.2        0.0        Ave Soil Loss (t/ac)  7.1     7.1      0.0
  Soil Value ($/ton)  4.00     4.00       0.00       Soil Value ($/ton)   4.00     4.00     0.00
  Value of Soil Lost 76.63    76.63       0.00       Value of Soil Lost  28.51    28.51     0.00

  Net Var Cost/Ac    266.21   220.61      0.00       Net Var Cost/Ac    192.75   153.26     0.00
  Net Var Cost/Bu      1.93     4.80      0.00       Net Var Cost/Bu      1.40     3.33     0.00
```

BRIAN DOYLE
ASCS FARM#: 3021
TRACT#: 2   FIELD#: 1

CONSERVATION PLAN

03-13-1989

FARMER NAME & ADDRESS:

BRIAN DOYLE
RR #1
LEXINGTON, IL   61753
MCLEAN COUNTY
Phone: (   )   -

FARM ACRES:

Corn: 72
Soybeans: 77
Sorghum:
Wheat:
Oats:
Meadow:

SET-ASIDE ACRES:

Legume: 7
Small Grain:
Other:

SOIL INFORMATION:

Soil Type (Complete soil Name): LA ROSE
Slope Steepness (Average, in %): 6 %
Slope Length (Average, in feet): 210 feet
Tolerable Soil Loss (tons/acre): 5 tons/acre/year

CONSERVATION PRACTICES USED:

None

CROP ROTATION USED:

Corn-Soybeans

ESTIMATED SOIL LOSS:

	Soil Loss (tons/acre/year)	Value Soil Loss ($/acre)	Variable Input Costs ($/acre)	Total Cost/Acre (Includes Soil Loss)
Present System:	19.2	76.63	166.01	242.65
No-Till System:	7.1	28.51	143.84	172.34

Average annual soil loss was estimated by the Universal Soil Loss Equation, based on information taken from your worksheet. If your soil loss under the No-Till System exceeds the Tolerable Soil Loss consult your local SCS personnel for additional practices or options.

Land Owner or Operator

SWCD Director

District Conservationist

Date

Date

Date

NO-TILL
USERS MANUAL
CORN-SOYBEAN ROTATION

MIDWEST EDITION

AGRONOMIC DEVELOPMENT CENTER
BASF CORPORATION

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NO-TILL USERS MANUAL

MIDWEST

BASF CHEMICALS

Prefix

When a farmer buys a new tractor or other farm implement, it comes with an operators manual which thoroughly details the operation, use, and trouble-shooting of the product. In contrast, when a farmer makes the decision to initiate a major change in his farming practice by converting to no-till, he has few organized guidelines to rely on.

The objective of the No-Till Users Manual is to provide the midwest farmer with a concise, organized, step-by-step reference manual to guide him through his conversion to no-till farming.

The information presented in this manual is a compilation of research and experience of innovative farmers, university personnel, industry and from BASF Research and Development.

No-Till Definition - For the purpose of the manual, no-till refers to planting in soil which is undisturbed in the spring. Some light tillage may be accomplished in the fall to manage residue, smooth out rough field conditions or lightly incorporate fertilizer and lime. A fall deep tillage operation may be required to prepare compacted soil for no-till the following spring. This is usually only an entry requirement.

Chemical Recommendations - Chemical recommendations made throughout this manual are general recommendations. Be sure to REFER TO THE LABEL FOR EACH CHEMICAL USED FOR SPECIFIC INSTRUCTIONS OR RECOMMENDATIONS.

Senator **Conrad**. Next we will hear from Dr. Stephen Marley, professor of agricultural engineering, the Leopold Center for Sustainable Agriculture. Welcome, Dr. Marley.

STATEMENT OF STEPHEN J. MARLEY, PROFESSOR OF AGRICULTURAL ENGINEERING, IOWA STATE UNIVERSITY, IN BEHALF OF THE IOWA STATE UNIVERSITY LEOPOLD CENTER FOR SUSTAINABLE AGRICULTURE, AMES, IA

Dr. **Marley**. Thank you, Senator, and good morning. I am here this morning to represent the Leopold Center at Iowa State University. The Leopold Center, I think, is unique among the States. It was established by the Iowa legislature in 1987 with the Groundwater Protection Act. It is funded from taxes and fees on fertilizer-nitrogen and pesticide sales, and its goals are to develop and promote agricultural systems that combine responsible stewardship of natural resources with farm profitability. It is charged with conducting research on the environmental and socioeconomic impact of ag practices. We do now have a director in place, Dr. Dennis Keeney, but only since September 1988, so the center is in the process of establishing issues and direction. I want to emphasize that it is very new. The center, other than the director, has really no staff, and the research that the center is responsible for conducting will be done through competitive grants. The center has already funded some projects to improve resource management through the use of no-till and conservation tillage.

It is involved in on-farm research with the group, Practical Farmers of Iowa (PFI). In 1988, about $700,000 was awarded through competitive grants for research. I did bring this brochure along that does list what those individual projects are—19 were funded in 1988. The center will be active in the future in advancing the technology of no-till and the role that plays in meeting soil erosion control requirements of past and pending legislation.

When you look at the spectrum of tillage from moldboard plowing to no-till, "minimum tillage" is somewhere in between, but generally not in the middle. The effect of any tillage seems to be closer to the moldboard plow system than to no-till.

The potential incompatibilities between no-till used for erosion control and the environmental concern for the use of herbicides possibly required for weed control with no-till, presents several topics for research that are appropriate to the Leopold Center. Application, and incorporation, of nutrients with no-till can also be a concern. Because of the past research performance of faculty at Iowa State University relative to conservation tillage, the Leopold Center does have a group of experienced scientists that are available to conduct research in this area.

There is also a history of close cooperation between USDA-ARS and CSRS scientists at Iowa State, and these people have provided much of the ercsion control data that has resulted in the advances such as the point-injector fertilizer applicator and will continue to be enhanced by the creation of the Soil Tilth Laboratory that is just opening this year. The center has active projects with the Iowa Department of Natural Resources and the Iowa Department of Agriculture and Land Stewardship, such as the integrated farm management demonstration program and the big spring demonstration project, and these have built a background of cooperation with State agency people.

Iowa has been a long-time contributor to conservation tillage/minimum tillage, and low tillage technology, and that dates back to the 1950's when one of the professors in agricultural engineering and the Iowa Agriculture Experiment Station developed a ridge-till system for corn production. But for a variety of reasons, including imperfect weed control, that system was slow to gain acceptance. By the early 1970's, the erosion caused by conventional tillage was well-enough recognized and was of enough concern that some farmers were adopting alternative practices.

There is a No-Till Farmer magazine that keeps track of some of those statistics. In 1973 they reported in Iowa 574,000 acres of no-till and about 5 million acres of minimum-till, out of 18.8 million planted acres. Figures for 1988 are 700,000 acres of no-till and 10 million acres of minimum-till out of 20,660,000 acres planted. And so one can see what is happening that the minimum-till system or low-till system has gained much better acceptance than no-till.

No-till crop production does have some problems and perhaps particularly in continuous corn. One of the first problems to arise is nitrogen fertilization. Because of its low cost, anhydrous ammonia is the predominant nitrogen fertilizer most commonly used. This product must be knifed into the soil, and once you do that, it may be hard to claim that you have a system truly no-till.

Same is true for weed control. If we control weeds with cultivation, we perhaps no longer have a strictly no-till system.

A third concern is the yield reduction that is frequently reported for no-till continuous corn.

So is the question of a possible adverse relationship between no-till agriculture and groundwater contamination as just mentioned by Mr. Kinsella. The scenario presented, I think, is much as he mentioned, but with the development of the macropores you do have water moving through that profile more rapidly than you would in the tilled field.

He also mentioned that it is not established that just because the water runs through that the fertilizer and pesticide contamination is worse. But I think that is one of the areas that does need some research. So these problems individually or in combination are not fatal to no-till. But there is little doubt, I think, that such questions slow its adoption. But there is still a good deal of research that needs to be done. Clearly, research is needed to answer the following questions:

What are the factors responsible for the yield reductions so frequently reported for continuous corn with no-till culture?

Or how can fertilizers be applied for maximum availability and uptake in no-till production?

What level of herbicide use is required for successful weed control in no-till systems?

And then if some herbicide use is required sometimes, what application practices will reduce the environmental risks to acceptably low levels?

So I think there is no doubt that research can provide answers for all of these questions. Support is a problem. And I am sure it will continue to be a problem, but the rate of progress is about proportional to how many resources are committed.

Senator CONRAD. Thank you very much.

[The prepared statement and attachments of Dr. Marley follow:]

STATEMENT OF STEPHEN J. MARLEY, PROFESSOR OF AGRICULTURAL ENGINEERING, IOWA STATE UNIVERSITY, IN BEHALF OF THE IOWA STATE UNIVERSITY LEOPOLD CENTER

The Leopold Center for Sustainable Agriculture was created at Iowa State University with passage by the Iowa Legislature in 1987 of the "Groundwater Protection Act." It is funded from taxes and fees on fertilizer-nitrogen and pesticide sales, and its goals are to develop and promote agricultural systems that combine responsible stewardship of natural resources with farm profitability. With the hiring of the Director, Dr. Dennis Keeney, in September of 1988, the Center is in the process of establishing issues and direction.

Through competitive grants, the Center has already funded some projects related to improved resource management through the use of no-till and conservation tillage, and is involved in on-farm research with the Practical Farmers of Iowa. The Center will be very active in the future in advancing the technology of no-till and the role it plays in meeting the soil erosion control requirements of past and pending legislation.

When viewed across the spectrum of tillage systems, no-till is on one extreme with the moldboard plow system on the opposite end, and the "minimum tillage" systems in between, but not in the middle. It is believed that any pre-plant tillage leaves a tillage system closer to the moldboard plow system than the no-till system in this spectrum.

The potential incompatibilities between no-till used for erosion control and the environmental concern for the use of herbicides possibly required for weed control with no-till, presents several topics for research appropriate to the Leopold Center. Application, and incorporation, of nutrients with no-till can also be a concern. Because of the past research performance of staff at Iowa State University relative to conservation tillage, the Leopold Center has a ready resource to call upon to study in this area.

In addition, the history of close cooperation between USDA-ARS and CSRS scientists in Ames, which have provided much of our erosion control data and resulted in such advances as the point-injector fertilizer applicator (see schematic), will continue and be enhanced by the creation of the Soil Tilth Laboratory. Also, active projects with the Iowa Departments of Natural Resources, and Agriculture and Land Stewardship, such as the Integrated Farm Management Demonstration Program and the Big Spring Demonstration Project, have built a background of cooperation with state agency people.

Iowa has been a long time contributor to conservation tillage/minimum tillage technology. In the mid - 1950's Dr. W. F. Buchele and the Iowa Agriculture Experiment Station developed a ridge-till system for corn production, but for a variety of reasons, including imperfect weed control, this system was slow to gain acceptance. By the early 1970's, the erosion caused by conventional tillage was well enough recognized and was of enough concern that some farmers were adopting alternative practices. For 1973, No-Till Farmer magazine reported 574,000 acres of no-till in Iowa and 4,942,000 acres of minimum-till, out of 18.8 million planted acres. Figures for 1988 are 700,00 acres of no-till and 10,184,000 acres of minimum-till out of 20,660,000 acres planted. Clearly, the minimum-till system ("any tillage and planting system that maintains at least 30% of the soil surface covered by residue after planting...") has gained much better acceptance than no-till.

No-till crop production is not without problems particularly in continous corn. One of the first problems to arise is nitrogen fertilization. Because of its low cost, anhydrous ammonia is the predominant nitrogen fertilizer. This product must be knifed into the soil, and it is hard to claim that a system is truly zero-till if it includes anhydrous ammonia fertilization.

Weed control is a second potential problem. If weeds are controlled by cultivation, we no longer have a no-till system, but weed control with herbicides is also acknowledged to have potential environmental problems.

A third concern is the yield reduction that is frequently reported for no-till continuous corn.

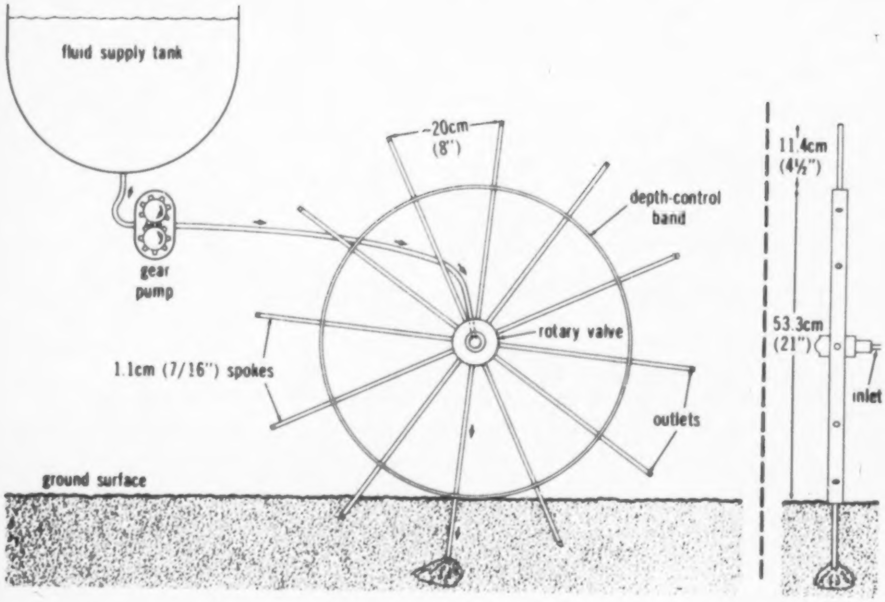
The question of a possible adverse relationship between no-till agriculture and ground water contamination has also been raised. The scenario presented is that as more or less permanent macropores develop in untilled soil, water flows more rapidly through the soil profile, possibly carrying with it surface applied fertilizers and/or pesticides.

These potential problems, individually or in combination, are not fatal to no-till (No-Till Farmer, January, 1989, reported 13 million no-till acres planted in 1988) but there can be little doubt that they slow its adoption. Clearly, research is needed to answer the following questions:

1. What are the factors responsible for the yield reductions so frequently reported for continuous corn with no-till culture?
2. How can fertilizers be applied for maximum availability and uptake in no-till crop production?
3. What level of herbicide use is required for successful weed control in no-till systems?
4. If some herbicide use is required sometimes, what application practices will reduce environmental risks to acceptably low levels?

There can be little doubt that adequately supported and well executed research can answer these questions. Rate of progress largely depends on the resources committed.

(Schematic and projects funded May 1988 follow:)


fluid supply tank
gear pump
~20cm (8")
depth-control band
rotary valve
1.1cm (7/16") spokes
outlets
ground surface
11.4cm (4½")
53.3cm (21")
inlet

Work is under way on all these projects. The articles on the next three pages highlight three projects to illustrate some of the diverse approaches to the complex problems of sustainable agriculture and the environment in Iowa.

Projects Funded May 1988

$25,000 for comparison of seven double-cropping systems designed to produce plant sources of energy (I. C. Anderson, D. R. Buxton, and A. J. Hallam, ISU).

$25,860 for a study using small grains or small-seeded legumes in narrow strip cropping to diversify crop production and provide environmental benefits (R. M. Cruse, W. F. Wedin, and S. K. Barnhart, ISU).

$27,849 to demonstrate the results of using a common fungus to control European corn borer (J. J. Obrycki, L. C. Lewis, and E. C. Berry, ISU).

$80,000 to conduct 25 on-farm demonstration trials of systems that reduce tillage, chemical inputs, and energy consumption (R. L. Thompson, Practical Farmers of Iowa).

$17,060 to compare chemical and nonchemical methods of controlling the strawberry leaf roller (J. J. Obrycki, ISU).

$24,730 to develop a nitrogen-flow model for use in minimizing nitrogen losses that pollute groundwater (D. Vander Zee, R. J. Vos, and C. L. Goedhart, Dordt College).

$11,880 to examine whether different soybean varieties vary in their beneficial effects on subsequent corn crops (R. Shibles and D. Green, ISU).

$26,500 to demonstrate ways to adjust fertilization practices to capitalize on the slow-release characteristic of anhydrous ammonia (A. Blackmer, ISU).

$79,704 to determine the distribution and severity of cases of northern corn rootworm extended diapause (J. J. Tollefson, ISU).

$27,470 to compare a high-input, low-management farming system, a low-input, high-management system, and an intermediate system (M. S. Honeyman, ISU).

$50,552 to compare tillage and herbicide alternatives for strip intercropping rotations (R. M. Cruse, D. C. Erbach, and Micheal Owen, ISU).

$25,256 to demonstrate energy-efficient irrigation and disease management on vegetable crops grown on sandy loam soils (H. G. Taber, M. L. Gleason, and S. Melvin, ISU).

$11,800 to compare the effects on drainage water of three systems of split-nitrogen applications and one system using a single nitrogen application (R. S. Kanwar and J. L. Baker, ISU).

$23,500 to examine the effects of conservation tillage on nitrate and herbicide leaching (J. L. Baker and P. Boddy, ISU).

$79,250 to establish a field hydrology laboratory to use in monitoring the effect of tillage and crop rotation on infiltration of agricultural chemicals into groundwater (M. S. Honeyman, R. Fawcett, and R. S. Kanwar, ISU).

$13,470 to demonstrate crop-scouting and soil-testing in low-input crop rotations and to establish an insectary for alfalfa weevil parasites (M. Buske, ISU; Gary Guge, Harrison County agriculturalist; George Gage and Terry Root, DeSoto National Wildlife Refuge, U.S. Fish and Wildlife Service).

$42,438 to demonstrate ways to conserve energy and soil in beef cattle production on erodable soils (J. R. Russell, D. L. Loy, A. Trenkle, D. R. Strobehn, W. F. Wedin, S. K. Barnhart, J. A. Hallam, and M. S. Honeyman, ISU).

$38,617 to examine use of a fast-growing, perennial tree crop to reduce nitrate movement into streams and provide wood fuel for burning (J. Schnoor and L. A. Licht, University of Iowa).

$107,540 to examine timber management and burner sizes and configurations in the production of wood for heating farm buildings and drying grains (M. S. Honeyman, P. W. Wray, R. B. Hall, T. Greiner, and D. Jones, ISU).

Senator **CONRAD**. I think what we will do, given our time constraint, is we will go to the second panel and then have our questioning and interchange with both panels together. As I look at the two panels, we have people who could participate in discussion on both panels, and that might be very beneficial if we do it that way. So let me give you some time off. Thank you very much, excellent testimony.

And if we can call the second panel. Dr. John Baker, the director of Agricultural Machinery and Research Centre at Massey University; Dr. Robert Papendick, research leader of the Land Management and Water Conservation Research Unit of Agricultural Research Service, USDA; and Dr. James Parr, the coordinator of USDA Dry Land Agriculture Project, Agricultural Research Service, USDA.

For those of you who perhaps might want to be able to see more clearly the presentation that will be made, it is a short videotape—of 5 minutes. You might want to arrange yourselves so you can see this monitor over here. I must say I have seen the lengthier version and have found it extremely interesting as well as exciting in terms of what it offers. With that, we will start with John Baker. Dr. Baker, welcome, good to have you here.

STATEMENT OF C.J. BAKER, DIRECTOR, AGRICULTURAL MACHINERY AND RESEARCH CENTRE, MASSEY UNIVERSITY, PALMERSTON NORTH, NEW ZEALAND

Dr. **BAKER**. Thank you, Mr. Acting Chairman and Senator Kerrey. I deem it a great honor to be invited to address you from outside of your society and outside of your country. But the similarities between much of what we do and much of what we seek to achieve in farming, I think, make it quite appropriate. My own position is that I direct the Agricultural Machinery Research Centre at Massey University which is in the center of New Zealand, largely in a temperate climate, which in some respects has given us something of a time advantage in the research that we have been doing in the sense that we can get into the paddocks every day of the year. That allows us, of course, to test the type of equipment that we had hoped to develop.

Our entry into the no-till research really was stimulated from the belief that we grew up with, that no-till offered a number of advantages in the whole agricultural system, particularly from a conservation point of view, although many of those are not terribly important to New Zealand because of the particular agricultural system that we have. But it was clear to us that no-till was not working with sufficient reliability for farmers to adopt it voluntarily.

I think that has proven to be the case as time has gone on. What worried us was the number of farmers who came into no-till who were countered by the number of farmers who went out of no-till under bad experiences, particularly from the point of view of crop establishment. We took the simple philosophical view that yield potential was simply not going to happen without a sufficient number of target plants that were being sown in the first place. So we targeted trying to determine what the seed responded to in untilled soils with a view to developing technology dictated by the plant and especially the seed requirements. It seemed to us that if we were going to have technology in the field to do that, it had to be able to cope with an extraordinarily wide range of conditions.

Under tillage, you tend to modify the conditions and you manicure those to the point where the seed sowing operation is a relatively minor technological achievement. Under no-tillage you do none of that except perhaps control the weeds. Therefore, the seed sowing operation, in fact, is the most sophisticated of all the operations that you do. So we had to have technology that was tolerant of both very dry and very wet conditions and of course tolerant of all of the conditions in between. We did not subscribe to the view that is commonly expounded that there are horses for courses in no tillage. Most individual farms have a range of soil types and certainly a range of conditions within any one soil type dictated by the weather and prevailing conditions, and clearly you cannot have a single drill for each of those conditions.

Biological tolerance, therefore, became the most important design criterion. We have been occupied in this since 1967 so it has roughly a 20-year history. The biological determinations that we set ourselves continue today. The mechanical design criteria were established after about the first 10 years. So we now have a simultaneous program of biological and engineering development. It would be fair to say that the particular slot that we eventually came up with is near to the inverse of the double-disk or the V-shaped slot that is commonly used throughout the world for no-tillage, and which incidentally is by far and away the least biologically tolerant of all slots that we have tested.

Senator CONRAD. Let me just stop you there. What you are saying there is that the drill that we use and the tillage system that we use most prevalently in American agriculture and world agriculture is the least acceptable biologically?

Dr. BAKER. Yes, that is exactly right. In all of the experimentation that we have done over 20 years, the double disk opener has always been at the bottom of the list in terms of performance. It is sometimes equivalent, of course, to other openers in good conditions. It has never been at the top of the list. Part of our philosophy was, therefore, that if with such an intolerant opener, no-till has proceeded as far as it has today, then the potential for more tolerant openers to launch no-till into a wider acceptance is quite enormous.

Senator CONRAD. I just think we should underline that point. What I hear you saying is that the system that we are using now is the one that is the least productive from your research.

Dr. BAKER. Indeed.

Senator CONRAD. I think that in itself is quite a story. Proceed.

Dr. BAKER. Thank you, Senator. Could we perhaps have the slides? There are just a few slides here which illustrate the points. I am not going to spend a lot of time on iron-mongery. There are other opportunities to see that. The slot that we came up with, as shown in the slide, we initially called an inverted T for obvious reasons, as you can see in the cut-away there. The characteristics of it are that the residue which is the single most important resource in no-tillage is returned exactly from whence it came over the seed and over the soil.

In fact, in sod it is very difficult to see where you have been, and we cannot drill at night because we just simply do not leave enough marks on the ground for the operator to see where the drill is operating, where the last cut was made. Making a slot of that shape gave us the opportunity to put seed on one side and fertilizer on the other. The disk slit, which in fact, passes between the two and goes somewhat deeper than both of them, together with the shape of the slot effectively separates seed and fertilizer so that seed burn from fertilizer is avoided. The yield responses of crops to that placed fertilizer are so encouraging that we think that we are fairly close to having it in the optimum position compared with most of the alternatives.

Can I have the next slide, please? There is a series of slides here that I will quickly pass through that illustrate, I think, very succinctly the ability of the opener to utilize the residue. This was taken in Nebraska with a single opener on tests in wheat residue. It is difficult to see where the opener has been, but the significant thing is that there is no bare soil exposed at all. The next slide, please.

A multirow drill through barley residue. Again, a little easier to see where the slots are, but still no visible soil. And again, please. This particular slide is taking in soil in Queensland, Australia, a particular sticky soil covered with light residue because of the climate, but again you can see the return of the residue to the slot zone.

And finally at the other end of the scale where the residue is very low, it is quite clear in this slide that what we have is short grasses returned to where they came from, still no major disturbance of the soil on the surface. This, of course, all happens under the soil. The effect that has on the plant is quite amazing. In a dry climate, the retention of water is clear. Impediment to germination and emergence is virtually nill. We have not measured any. Any impediment to germination that comes from residue is when the residue is pushed down into the slot and decays near the seed, and the phenolic acids produced kill the seed. That does not happen with this opener. It is a specific aspect of it that allows you to use the residue to advantage.

The technology can be downscaled and has been downscaled to Third World countries in a simpler form, but it loses nothing of the effectiveness in that situation.

Quickly, a summary here of experiments over the years conducted in dry soils. I would draw your attention to the green column on the right. The magnitude of difference is what has spurred us on for so many years. We are talking about 1,400 percent increase in numbers of seedlings in dry soils at the top, ranging down to a 20 percent increase in lower soils. And I will also draw your attention to the——

Senator **Conrad**. A 1,400 percent increase in?

Dr. **Baker**. In numbers of plants.

Senator **Conrad**. In numbers of plants.

Dr. **Baker**. Yes.

Senator **Conrad**. We are holding seeding constant here.

Dr. **Baker**. Yes.

Senator **Conrad**. And you are getting 1,400 percent increase over traditional methods. That is the comparison here.

Dr. **Baker**. Now the comparison is actually within no-till. You made the statement before, and I think this illustrates it, that the worst treatment, if you like, has been the double disk shown there as TD in the blue column. It keeps appearing on the right hand side, the worst treatments. So we are talking about a 1,400-fold increase, 1,400 percent increase of numbers of seeds with the cross-slot, which we call the new slot, compared with the V-shape of the double disk opener.

Senator **Conrad**. All right.

Dr. **Baker**. Those, of course, vary with time, but that is a range over time. The final slide simply summarizes the highlights of the different experiments that we have done. Quite simply the highlights are, as we said in dry soil, something in the order of 1,400 percent. In wet soils, interestingly, we have had something like 4½ times as many seedlings emerge, or 400 percent more seedlings emerge than with the double-disk opener. In optimum soils, there have been yield increases from the cross-slot opener, given that the plant establishment stands have been similar with comparative openers. There is still a yield increase resulting from, firstly, the fertilizer placement, and secondly, the vigor of the seedlings which emerge.

It is one thing to count the number of seedlings. It is another thing to have vigorous seedlings emerging, which, of course, sets your yield potential from the beginning. In summary, the comment that I would have to make, which I believe is important, is that there probably never has been an item of farm machinery introduced on to the farming market about which so much is known in scientific terms before the farmer has seen it.

We have tended in the past, all of us, to take machines, to experiment with them, to test them and learn a lot about them after the event. In this case, we know a lot about it before the event. And perhaps I would seek your indulgence to run that short video.

Senator **Conrad**. I think that would be very helpful. I think it would be very helpful to everybody's understanding to run the video so let us do that.

[Videotape presentation made.]

[The prepared material of Dr. Baker follows:]

DEVELOPMENT OF THE CROSS SLOT NO-TILLAGE TECHNOLOGY
(a summary)

Submitted to the United States Senate
Subcommittee on Agriculture Research
and General Legislation
Wednesday, March 15, 1989

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Agricultural Machinery and Research Centre
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INTRODUCTION

Development was initiated in 1967 in response to international evidence that the technique of no-tillage had outstanding potential to reduce soil erosion, time and energy during crop establishment. Despite this exciting potential however, farmers were not obtaining consistent plant stands nor yields with the technique.

The cultural objective of the work was therefore to reduce biological risks at the time of planting.

The scientific objective was to define the requirements of seeds and seedlings in an untilled soil and thereby to write the specifications for improved hardware.

In achieving these objectives studies were made of the interactions of openers with the following parameters:

Dry (drying soils);
wet soils;
"optimum soils";
sticky soils;
pasture;
sportsturf;
standing crop residue;
lying crop residue;
crop species;
seed size;
ambient conditions;
fertilizer type and rate;
seed inoculant;
soil type;
soil texture;
soil organic matter;
soil fauna;
pests;
weeds;
topography;
forward speed;
downforce system;
drag arm geometry;
multiple passes;
the method of herbicide application.

The studies have involved seventeen post-graduate students and five staff over the years. They continue today.

BIOLOGICAL RESEARCH

An approach was adopted which sought to test the responses of seeds to extreme soil conditions since optimum soil conditions were considered less likely to unmask differences between or weaknesses within openers. In order to achieve this, a unique tillage bin facility was designed in which large bins of undisturbed soil were removed from the field and seed was drilled into them in a laboratory. They were then returned to a climate-control room in order to impose predetermined climatic stresses. Mechanical functions of the range of different openers tested were able to be standardized, measured and controlled using such a technique.

Not only were counts of final emergence of seeds and seedlings made but care was taken to ascertain why seedling emergence failed and how this was effected by the machine in the soil.

To date the technique has established that openers have a direct influence on the following parameters.

slot shape (V, U or inverted T);
nature of the slot cover;
slot microenvironment;
slot smearing and compaction;
pressing and packing of the soil;
depth of seed;
ejection of seed into the slot;
changes in soil structure;
infiltration of the rain into the slot zone;
behavior of soil fauna;
fertilizer placement and effectiveness;
behavior of competing vegetation;
behavior of surface residues;
micro-management of surface residues;
draft of the machine;
downforce required to achieve sowing depth;
wear of mechanical components;
soil/metal scouring;
crop yield.

Later in the programme as technology was developed and confidence of crop establishment under a range of biological conditions was gained, the team examined new cultural practices that were hitherto not considered possible in the absence of safe and risk free establishment. These practices included the renovation of pastures on both flat land and hills, renovation of sportsturf on playing fields, golf courses, and horse racing tracks, establishment of crops in innovative rotations (including three crops per year), establishment of combination rotations between crops and pastures, establishment of a second crop after paddy rice in Asia and the utilization of surface residues after crops as an important resource rather than a mechanical nuisance.

OPENER DEVELOPMENT

A. The first opener developed was a simple winged tool which created an inverted T slot. This has formed the basis of three seed drill types.

1. Post rice seeder.

   A small single row drill which is drawn by an animal or walking tractor has been designed for use in Asia in establishing a food crop after the harvest of paddy rice in soils which are drying, shrinking and structureless. Hitherto little success had been gained in establishing such crops because of the intolerance of equipment to this hostile soil environment.

2. Low-cost pasture renovation machine

   Several manufacturers in New Zealand and Australia have utilized the technology to produce inexpensive tractor-mounted machines for renovating pastures, sometimes on an annual basis.

3. Mid-range drill

   A mid-range drill is under development for cropping use in those development countries where little residue remains after the previous crop.

B. The advanced opener (now called the Cross Slot) was evolved from the simple opener. The most compelling design criterion was to maintain the inverted T shape of the slot in soils covered with crop residue. Such a slot had clear biological advantages over any of the existing openers tested and/or reported anywhere in the world. The advanced version of the opener sought to add to this biological excellence, additional functions necessary in a fully intensive no-tillage system. Accordingly the cross slot opener is capable of handling considerable surface residue without blocking; accurately controlling the depth of seeding; placing fertilizer in the same slot as the seed but separating them in such a manner as to avoid seed burn by the fertilizer but maximizing plant response to the nutrients; micro-managing the residue so as to create a near-perfect microenvironment within the slot; self closing the slot, and making provision for banded application of herbicides where pre-drilling blanket spraying is not desirable. This opener has formed the basis of several drill configurations.

1. A single row drill directly mounted onto wheel and crawler tractors which enables the sowing of edible shrubs on steep hillsides in countries subject to hillside erosion and devegetation by animals.

2. A grain drill for the sowing of small grain cereals, pasture, turf pasture, etc. In order to provide such drills with the capability of accurately following the contour of untilled ground a special and sophisticated hydraulic system was also developed and patented internationally.

3. A wide-row precision seeder for corn, soybean and vegetables together with a super wide-row air seeder for prairies are also under development.

With all machinery development, biological performance has been the first measure of success or failure. Mechanical performance has been secondary until advanced prototypes have been evolved prior to commercial release of the technology.

A total of four series of prototype seed drills have been constructed over the years. These seed drills were used to custom drill for farmers on approximately 100 different properties involving about 300 different fields, soil types, topographies, weather conditions, and farming systems throughout New Zealand and Australia.

New Zealand itself is an exceptionally good test bed for development of such equipment because of its mountainous micro-climatic nature which allows researchers to test machinery in the great majority of the world's climatic, topographical and soil conditions within two to three hundred miles of traveling time from the University, and in a temperature climate which allows field testing to be conducted virtually every month of the year.

QUANTITATIVE RESULTS

Highlights of the extensive collection of biological results comparing the cross slot technology with conventional technologies is seen in the following summary.

In dry soils over 1000% increases in wheat seedling emergence have been obtained, compared with double disc openers. On no occasion over twenty-one years has any opener of opener/covering combination outperformed that obtained with the inverted T (cross) slot in terms of crop stand.

In one experiment fifty percent emergence of wheat was obtained with the cross slot where no emergence at all was obtained with hoe or double disc openers, nor under tilled conditions with conventional drills.

In wet soils a four hundred percent increase in emergence has been obtained with the cross slot compared with a triple disc opener, and a fifteen percent increase compared with a hoe opener. Strong and interesting interactions with earthworms which permeate the slots were shown together with second order interactions between residue placement by the opener, earthworms and the slot shape.

In "optimum" soils the separate placement of fertilizer and seed with the cross slot opener has resulted in an average of fifteen percent greater yield from crops grown with this opener compared with deep placement of fertilizer by double discs in a series of experiments spanning two years in the United States.

The range of crops used in tests with the technology has included: pass, rape, kale, safflower, sunflower, soybean, broad bean, pumpkin, squash, gherkin, tomato, lettuce, sweet corn, snapdragon, borage, tick beans, lupin, fodder radish, sulla, turf grass species, rye grass, tall fescue grass, prairie grass, Yorkshire fog grass, phalaris grass, cocksfoot grass, white clover, red clover, lotus species, wheat, barley, corn, triticale, oats, turnip, millet, tares, sorghum, chicory, alfalfa, sheeps burnett, and many others.

SUMMARY

While biological differences between openers in "optimum" soils can be expected to be modest, as soil moisture conditions deteriorate in either direction the superiority of the cross slot opener increases. Clearly this technology has gone a long way towards eliminating biological risks at planting and thereby increasing crop yields and profitability. By so doing it also invites the lowering of inputs into sustainable agriculture.

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ADDITIONAL RESEARCH NEEDS

Desication of crops with glyphosate studying the effects on yield, seed germination, perennial weed control, effects on weed seed viability and optimum crop stage.

Microbial changes in long term 0-till and possible effects on chemical breakdown and groundwater quality.

Does increased earthworm activity cause faster herbicide decomposition, or conversely, does the more porous soil allow surface water, which has absorbed chemical, to reach the water table more quickly?

Glyphosate resistant crops and their potential in 0-till.

Evaluation of a wide range of crops such as fall rye, alfalfa, and other forage crops and their potential in 0-till.

Damage from herbicide residue under different soil, pH, soil type, climatic conditions, available soil moisture, especially when used as a spring burndown.

Variety comparisons under 0-till.

Senator **Conrad**. I thank you very much for bringing that to us. I think that video does make clear the technology that has been developed, and I for one think it is extremely exciting what you have done. I would like to see this being tested in my State, because of the extreme drought conditions that we have encountered. This provides some hope to our farmers that you are going to have a technology that takes advantage of the moisture that is available. Really, that is one of the greatest advantages to this cross-slot technology; am I correct in that?

Dr. **Baker**. Yes, that is correct. I have no doubts as to the adaptability of it to a range of different conditions. Certainly, the originating principle has added to it all of the other desirable aspects of no-tillage. Senator, I would like to leave with you in appreciation of your stimulation in this area a complete history of the cross-slot technology.[1] I appreciate that it is too big to submit as evidence, but I would nevertheless like you to have it.

Senator **Conrad**. Thank you very much. We appreciate having it. Next we will hear from Dr. Papendick, research leader, Land Management and Water Conservation Research Unit of the Agricultural Research Service of USDA. Dr. Papendick.

STATEMENT OF ROBERT I. PAPENDICK, RESEARCH LEADER, LAND MANAGEMENT AND WATER CONSERVATION RESEARCH UNIT, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE, WASHINGTON STATE UNIVERSITY, PULLMAN, WA

Dr. **Papendick**. Thank you, Senator Conrad.

Senator **Conrad**. I hope I am pronouncing your name correctly.

Dr. **Papendick**. That is correct. It has been called a lot of other things, but you are right on target. Thank you, Senator Conrad, for this opportunity to make a few followup remarks on the USDA research regarding conservation farming in general, but also on some of our work with the cross-slot technology. The USDA-ARS program at Pullman, where I am, has been conducting research on conservation tillage for over 20 years, and much of this work has emphasized the development of no-till and minimum-till systems. This research as well as other research has shown that surface crop residues are the most economical and effective resource that farmers have available for controlling erosion over a wide range of climates, soil, and cropping conditions.

But the research has also identified some of the biological, physical, and mechanical factors associated with crop residues that limit yields and in turn limit the widespread adoption of the conservation systems by farmers. One of these major limitations involves the availability of seed drills that are capable of planting in trashy seedbeds without doing excessive and unnecessary tillage, while at the same time obtaining good stands of crops, especially under submarginal moisture conditions.

Much of our research in the past on conservation tillage has involved the use of double disk and hoe-type seed openers. Problems encountered with this equipment include plugging with straw, burying too much of the residues and too often, inconsistent and poor stands with conservation seedings.

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[1] The material "Development of No-Tillage Technology" at Massey University, New Zealand, by Dr. C.J. Baker is retained in the subcommittee file.

Also, the heavier built commercial machines that could operate over a wider range of conditions were quite expensive. They have large power requirements and are affordable only to large scale farming, and moreover, are geared for high input technology.

Our long-term research goal here at Pullman is to provide a conservation technology that overcomes some of these previously identified limitations of surface residue farming and also that can be economically accessed by a range of farming sizes. About 3 years ago we began to conduct adaptive research on the drill opener invented by Dr. John Baker from New Zealand which now has been termed the cross-slot by the USDA.

We are very encouraged by the results of this research and we feel optimistic that this technology has the potential to move U.S. agriculture much further ahead in the application of conservation farming and environmental protection than anything we have had before. Let me elaborate on just a few points of our research findings.

First, the opener operates very efficiently in heavy surface trash and in hard soil and does very little disturbance of the soil surface.

Second, the power requirements of this opener in no-till are considerably less than for hoe or double disk openers that simultaneously place seed and fertilizer.

Third, stand establishment with the cross-slot opener is generally superior to that with the hoe or double disk openers, especially under suboptimal moisture conditions which is very common in dry land regions. The reason for these better stands, we believe, is that the cross-slot opener uniquely places the seed in firm soil and does not push or mix residues into the seed zone.

Fourth, the potential for disease and other adverse biological effects on seedlings associated with surface residues is minimized because the opener does not tuck or mix the residues into the seed zone, which is very different than the other openers that we have been using.

Also, as already discussed, the past year results of experiments conducted by Dr. Keith Saxton of our research unit showed a wheat yield increase of about 15 percent compared with double disk openers over a wide range of tillage and residue conditions. We have also obtained significantly higher pea and barley yields with cross-slot planting compared with double disk seedings, and much of this we credit to the fact that we have been able to do a better job of getting stand establishment in the surface residue conditions.

Because of the unique method of fertilizer placement, the cross-slot technology should enhance the application of other conservation systems such as ridge till which is growing considerably in use for corn and soybean production in the Northern and Midwest States. The research with the cross-slot technology thus far appears very encouraging for expanding conservation benefits to the farm.

However, as a researcher, I feel that we need a strong research program in adaptive research. It should be continued to ensure success in expanding the use of this technology and to maximize its benefits to farmers both in this country and abroad. We need to study its use for a range of crops and cropping systems and how we can maximize its benefits for conservation systems other than no-till and minimum tillage including strip till, ridge till, and mulch till. We also need to continue a strong research emphasis on why the seeding and fertilizer technology works so well and how its performance can be improved even further for a range of soils, crops, and cropping conditions.

The research by the Agricultural Research Service at Pullman is also concerned with water quality improvement and also low-input sustainable agriculture as part of conservation farming objectives. We are very optimistic that the cross-slot technology will help us achieve our goals in these areas also. Just three points in this regard:

First, the opener makes possible more precise control of fertilizer placement and synchronization of fertilizer placement relative to the seed. This should increase fertilizer efficiency and reduce the amount of fertilizer needed.

Second, the fertilizer placement technology should reduce the need for fall or off-season fertilization for spring crops and thus minimize the potential for over-winter leaching of nutrients and also increase fertilizer efficiency.

Third, the seed opener technology should also encourage increased use of off-season cover crops and legumes in set-aside acres by enabling direct seeding into the residue mulch and retaining its benefits for erosion control and water conservation for the succeeding grain crop. Thank you.

[The prepared statement of Dr. Keith E. Saxton, research argricultural engineer, follows:]

SUBMITTED STATEMENT

OF

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PREPARED FOR SENATE HEARING
ON
CONSERVATION TILLAGE TECHNOLOGY RESEARCH: IMPLICATIONS FOR A SUSTAINABLE AGRICULTURAL

MARCH 15, 1989

WASHINGTON D. C.

Subcommittee on Agricultural Research and General Legislation
of the
Senate Full Committee on Agriculture, Nutrition, and Forestry

NEEDS AND NEW DEVELOPMENTS
OF
CONSERVATION-TILLAGE GRAIN DRILL OPENERS

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Abstract

Conservation tillage is the most commonly acceptable practice to protect a vast majority of the US and worldwide farmlands. Seeding and fertilizing are the most difficult operations to consistently perform well in a residue covered surface for establishment of subsequent crops. A new grain drill opener for seed and fertilizer placement in conservation-tillage is described. This opener, first developed in New Zealand and recently modified and tested in the U.S., utilizes a single, sharp disc running straight in the direction of travel to penetrate residues and soil. Two winged side blades raise the soil for simultaneously placing seed and fertilizer on opposite sides of the disc. Two packer-depth wheels immediately follow each disc to reset the raised soil and residue, firm the seed zone and maintain individual depths of each opener. Performance is significantly different from the traditional double-disc and hoe-type openers. Very minimal residue and surface soil disturbance occurs. Research results show excellent stand establishments in both tilled and untilled soils with and without surface residues, especially in sub-optimal soil and climatic conditions.

Introduction

Maintaining all or a portion of the previous crop residues while preparing and seeding a subsequent crop is now recognized as one of the most effective and widely applicable conservation practices available (Moldenhauer et al., 1983; Saxton, 1987; Schertz, 1988). Through the use of new chemicals and tillage implements, it is possible to maintain crop residues on or near the soil surface for effective soil conservation from wind and water. There still remains the challenge of routine and effective seed and fertilizer placement for succeeding crops on residue-covered fields, especially following cereal grains. Common problems are lack of seeder penetration, uneven seeding depths, straw tucked into the seed furrow, and poor seed-zone environments resulting in unreliable crop stands and yields.

Regardless of conservation tillage benefits, these farming methods must entail no more risk of crop failure or reduced yields than conventional tillage methods if they are to be acceptable to farmers. A common perception, largely based on early experience, has been that as a farmer moves closer towards no-tillage, the biological risks will be higher due to weeds, diseases, poor stands; and thus reduced yields (Massee, 1983). Conservation-sensitive economists have had to use these adverse yield results while trying somewhat vainly to convince farmers that the advantages of conservation tillage more than offset the inevitable yield penalties (Young et al., 1984, Taylor and Young, 1985).

We now know through more recent research and farming experiences that conservation tillage farming can in fact produce equal or better yields if proper machinery and methods are applied (Walker, 1983). But neither the machines or methods for conservation tillage can be reliably extrapolated from those for conventional tillage because of the hitherto untapped resources of untilled soils together with different field situations and agronomic needs. A new system of machines, chemicals, and methods must evolve.

Seed and fertilizer placement has continued to be one of the most troublesome operations causing risky and poor performance in conservation tillage, especially in cereal grain production (Lindwall and Anderson, 1977; Payton et al., 1985; Erbach et al., 1983; Wilkins et al., 1983; Babowicz et al., 1985). Most conservation tillage seeders have been adaptations of conventional machines and thus have not performed acceptably in many situations. For conservation tillage (especially no-tillage) to succeed, biological risks of stand establishment and growth must be less than or no worse than those of conventional tillage.

It has been common to assume that designs of conservation-tillage tools should arise by extrapolation from tools designed for tilled seedbeds with only relatively minor modifications for robustness. This assumption has now been shown to be flawed in numerous ways. For example, because of the availability of high-humidity vapor-phase water in an untilled seedbed on which surface residue has been carefully managed (including micro-management during drilling), it is now clear that such a seedbed has more potential to germinate seeds and emerge seedlings than a tilled soil, especially when the soil is dry (Baker, 1976). The method of creating no-tillage drill slots has a major effect on the loss rate of soil water vapor (Choudhary and Baker, 1981b). Compared to tilled seedbeds, residue covered soils often have different depth patterns of soil moisture, temperature, and densities in the seed zone, thus seeding depths and methods must also be different.

Current Openers

Slot shape and soil and residue cover of the seed furrow are the single most important biological variables in opener design (Baker, 1976). In this respect, most drill openers until recently have created essentially two shapes of soil slot with some minor variations within each. These are "V" and "U" shapes.

V-shaped slots are created by double or triple disc configurations.. Their most advantageous features are an ability to physically handle surface residue without blockage and to incur low maintenance. These attributes are countered, however by: 1) an inability to optimize the seed-zone micro-environment, particularly water vapor retention and oxygen movement in both dry and wet soils (Choudhary and Baker, 1981a; Baker et al., 1987, 1988); 2) a tendency to smear and compact slot walls (Baker and Mai, 1982) which induces embryonic root-stress at the near-vertical slot-wall interfaces; 3) a tendency to tuck residue into the slot where it affects germination by releasing phenolic acids upon decomposition; 4) a wedging action in the soil which creates little loose covering material; and 5) a marked dependence on slow speeds to avoid "seed-flick" by the discs. There is little opportunity for simultaneous but separate placement of fertilizer and seeds in V-shaped slots since the shape itself tends to concentrate them together at the base of the slot producing an undesirable interaction. Most designers have reluctantly utilized separate and additional fertilizer openers to avoid contact, but this has introduced additional demands on drill design and tractor power.

U-shaped slots are created by a wider range of openers than V-shaped slots, so generalizations become more difficult. For example, various hoes, flat-angled discs, dished discs, and power-till openers all create various configurations of U-shaped slots. These openers produce seed-zone micro-environments somewhat more optimal than V-shaped slots, but yet cause tillage, moisture loss, and randomized seed-soil contact. They all produce loose soil which can be utilized later for slot cover, albeit that little micro-control is exercised over surface residue in the vicinity of the slot. The residues are indeed often swept aside as a prerequisite to avoiding opener blockage resulting in loss of moisture control, although this also avoids residue tucking.

Separated fertilizer placement in the vertical plane has been achieved with modifications to hoe configurations, although the success of this action is very dependent on soil-plasticity and machine speed and the soil below the seed is often quite fractured and of low density (Wilkins et al., 1983; Hyde et al., 1979). Disc and power-till openers have similar problems to V-shaped openers in this respect although there is less tendency to collect seed and fertilizer together at the base of the wider U-shaped slots

While U-shaped slots may experience soil smearing and compaction when made with either hoe or power-till options, this is usually not accompanied by side-wall or slot-base compaction, and dished disc and angled flat disc options are mostly free of smearing tendencies altogether. Similarly, because the slot wall interfaces of U-shaped slots include broader bases than V-shaped slots, root penetration is less restricted. Both U- and V-shaped slots benefit from pressing seeds into the base of the slot as this action partially eliminates the need for embryonic roots to negotiate any slot-wall interface and in this respect leaves them in a similar position to a tilled soil where slot interfaces are rare(Baker and Choudhary, 1988).

Hoe type openers have difficulty passing through heavy residue without blocking unless individual openers are spaced widely apart which creates undesirable spatial demands on drill designs. They are, however, usually constructed of components which are inexpensive and less stressed compared with angled discs (flat or dished) and power-till alternatives. As with V-shaped slots, the measure of economic viability depends on the value put on the risk of stand loss, although such a risk is generally lower with U-shaped slots than V-shaped slots (Baker and Desborough, 1984).

The Cross Slot Opener

The cross slot configuration was developed at Massey University, (Palmerston North, New Zealand) beginning in 1969 when researchers were attempting to create a slot shape which contrasted with V- or U-shapes for comparative purposes. Geometrical options were limited and eventually the wide-top-narrow-base features of V-shaped slots were reversed to produce a narrow-top-wide-base inverted T-shape. Such a shape could realistically be created by a shank with lateral wings, although attempts were made to use paired dished discs for this purpose but their action was found to be too speed dependent.

Biologically, the cross-slot configuration has consistently produced significantly better seedling emergence results than either V- or U-shaped slots (Baker, 1979). This shape has especially increased the tolerance of seeds sown into soils that are sub-optimal (too dry or too wet). For example, advantages in seedling emergence as high as 140% compared with V-shaped slots have been recorded in dry soils. Fifty percent emergence of wheat was achieved from the cross slot in a soil at almost wilting point which had no emergence with V- or U-shaped slots (Choudhary and Baker, 1982). In a residue-covered soil containing a good population of earthworms which was wetted with 420 mm rain over 21 days after drilling, the cross-slot opener produced 75% emergence of barley while V- and U-shaped slots promoted only 17% and 65% emergence respectively (Baker et al., 1988).

The dry soil performance from the cross-slot has been shown to be a function of vapor-phase moisture retention within the slot (Choudhary and Baker, 1981b). It has been determined that this moisture retention is controlled by the diffusion-resistance of the soil and residue slot cover. The increased germination and emergence of the cross-slot configuration can be attributed to its capability to return residue-covered soil back over the slot from whence it came; i.e., seed-zone micro-management of soil and residue (Baker and Choudhary, 1988).

Wet soil performance has also been linked to residue retention over the slot while simultaneously avoiding tucking of it into the seed zone. In this case the residue has greatly influenced mobility and numbers of earthworms which provided more oxygen diffusion and infiltration into the seed zone than other opener types (Baker et al., 1987 and 1988).

As a result of early repeatedly promising biological results, mechanical solutions to other problems with cross slot openers were given high priority. Over a period of 10 years, engineering answers have been found to fertilizer placement (Baker and Afzal, 1986), residue handling and machine wear. These were combined to form the basis of an internationally patented opener design (Baker et al., 1979). The vertical shank of the simple original winged tool was split longitudinally. Each side of this dissected shank, with its horizontal wing, was positioned so the front edge rubbed on a central disc. The contact force and blade position were designed to be self-adjusting through soil pressure.

Seed is deposited on a soil shelf on one side of the coulter, while fertilizer is deposited on the other side

The fertilizer depth may be at or below the seed level. While the horizontal separation of seed and fertilizer is only about 20 mm., it is intersected by the vertical disc cut and is neither speed nor soil-plasticity dependent. Numerous field and laboratory studies have shown such separation to be predictable and effective from both crop stand and yield viewpoints (Baker and Afzal, 1986). Placing fertilizer with the same opener which sows the seed greatly simplifies the complete drill design.

While any slot created by a sliding rigid tool of this nature produces some smearing in wet soils, smears only appear to be noticeably restrictive to root penetration when they are permitted to dry and become in-groove crusts. Because of the self-closure and humidity-retention properties of the cross slot, internal drying and crusting are minimized. In addition, slot-base compaction is largely avoided because the wings travel with a forward incline (lift) of 5 degrees to the horizontal which is maintained with parallel drag arms between the drill frame and the openers.

The intimate contact maintained between the winged side blades and the disc ensures that heavy residue can be handled without blockage. With the aid of angled packer wheels, the residue-covered flaps of soil which are hinged up by the wings to allow deposition of seed and fertilizer are carefully folded back from whence they came to produce a residue-covered soil surface over the seeded row. The cross-slot opener is not speed-affected. Excellent seed deposition has been recorded at speeds up to 14 km/hr.

As with any slot shape, seed depth control is a function of both the depth-controlling wheels or skids and how the opener releases the seed underground. In this respect, the cross-slot opener design is capable of seeding with a high degree of accuracy. Depth control is with packer wheels positioned just rearward of the seed drop on each opener. Many designs have given low priority to this fundamental function of no-tillage openers which by definition will always be operating on fields which are at best unsmoothed by final tillage operations and at worst are deliberately roughened by primary tillage or weeding operations.

The cross-slot opener design requires high performance manufacturing to maintain necessary tolerances and rigidity. It is thus a relatively expensive capital tool although the replacement soil engaging components are both inexpensive and easily changed. The economic viability of the tool will therefore be dependent on: 1) its higher biological reliability and tolerance compared with other technology and 2) its wide applicability over many types of soil and residue conditions for a variety of farming styles and needs.

Example Test Plot Results

Winter wheat yields were summarized from plots using two conservation tillage drills -- a large diameter leading-edge double disc type and a cross-slot type. These were variously tilled fallow test plots in east-central Washington State, USA. Eight large plots (30 by 120 m) were seeded with field scale drills (6 and 8 m widths). Both drills banded the fertilizer at seeding time parallel to the seed row--the double disc between pairs of rows and 10 cm deep and the cross-slot about 2 cm beside and either at the same depth or 2- to 5-cm below the seed depth for each row. In the pre-seeding fallow tillage, the chiseling was a very shallow surface roughening, the discing was a shallow surface pulverization, cultivation produced a very deep tillage and very rough surface, and the no-till was a quite smooth and firm surface. All plots had a very low rate of the previous crop residues (approx. 0.2-0.5 t/ha).

Both drills had difficulty maintaining depth control in the loose, chiseled ground, but the cross-slot was able to do much better because of its individual depth control packer-depth wheels. The early spring stand counts (3-5 leaf stage) for these same plots reflect the seeding depth and seedling survival capability from the two drills. Notable was that both drills had their best stands established where no previous tillage had been done (chemical fallow) during the preceding fallow year. The lower stand counts resulted in less yield not only due to the fewer plants but because of increased weed population with less plant competition. These results demonstrated: 1) that the cross-slot opener performed better in a wide variety of soil surface tillage conditions, and 2) better yields were achieved in this soil and climate with no tillage during the fallow period by using chemical weed control.

Wheat yields were also summarized from seven separate experiments at two locations in eastern Washington State USA which had direct comparisons with the double-disc and the cross-slot type of openers. These mean values were not weighted by size of experiment or samples taken. The results were for both spring and winter wheat varieties with and without fertilizer. Each drill was used on the same day in identical conditions on randomized plots in as precisely the same manner as possible with regard to fertilizer and seed rates for each experiment. In all experiments, the cross-slot opener produced higher yields than the double disc. An average of all seven experiments which included 236 individual plot samples, showed that the cross-slot produced 4140 kg/ha compared to 3585 kg/ha for the double-disc, a 15.3 % increase.

Conclusions

Conservation-tillage, as a soil conservation practice of unparalleled merit, has progressed since its inception in the early 1960's to where even the skeptics no longer doubt that it is an effective conservation practice and can produce equal or improved yields compared to conventional tillage. Widespread adoption of the technique, particularly in cereal grain regions, has been severely restricted because of drill capability for stand establishment and simultaneous placement of fertilizers. The cross-slot drill opener and its associated technology offers a higher level of mechanical capability and biological tolerance with minimal risk to the farmer for conservation-tillage seeding.

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Senator CONRAD. Thank you very much. I might just break the routine here and have a chance to ask you a couple of questions because your testimony has raised a number of questions in my mind. Basically, when we are dealing with cross-slot, we are dealing with an opener that shows in the soil a pattern like this. When we are dealing with double disk, I should say, we are opening a V-shape opening in the soil, and that does two things, as I hear you talk. It allows us or has the residue going down into the slot or into the opening which gives you disease problems. It also opens up the soil in a way that gives us tremendous evaporation rate.

Dr. PAPENDICK. Right.

Senator CONRAD. We are drying out the seedbed in effect.

Dr. PAPENDICK. That is correct.

Senator CONRAD. The cross-slot is a T-shaped opening that is created so you have very little evaporation loss, and you have the chance to really create optimum conditions for a seedbed. Is that the basic thrust of what we are hearing? That you have a minimal loss of moisture and you create a situation in which you are able to put the fertilizer in almost perfect relationship to the seed?

And it is that combination that gives you superior results to traditional method?

Dr. PAPENDICK. I think you are exactly correct. Your point about the dropping—what a double disk drill essentially does, except under very rare conditions, it essentially passes through the soil and pushes the residues down. It does not necessarily cut them. It cuts a lot of them, but it will not cut them all. Drops seed on top and then soil will fall back in. So that in many cases, the seed just sets on the straw. And this does two things. One, it prevents good seed soil contact, which is very essential for rapid germination and emergence.

The second thing is it exposes these seeds to possibilities of infection by organisms that are decomposing the straw. For example, pythium, it is well-known now that that is a problem. Now the cross-slot, on the other hand, what it does is it creates a cavity in clean soil away from the——

Senator CONRAD. Residues.

Dr. PAPENDICK [continuing]. Residues. There is no tucking. Tucking does not matter because it is over off to the side. So it is in clean soil, and as Dr. Baker has pointed out, that cavity is sealed so the humidity can remain high, and you get better germination. Our success, we have never been able to be produce, for example, no-till peas with double disk seedings to any degree of success. When we used the cross-slot for 2 years now in heavy residues following wheat, we increased yields by about 25 to 30 percent. And we credit it to the stands. We can get stands now for the first time. We never could before.

Senator CONRAD. This is pretty dramatic results that you are reporting. In your experience have you ever experienced something that showed these dramatic results? Have you ever experienced something that——

Dr. PAPENDICK. With surface residue farming, no, no, I have not. We have just not encountered any kind of seeding. I think it is the unique placement of the seed, and of course, the fertilizer is also an advantage because we have more control over it now. We can control it. We can place it in wherever we want to in relation to the seed, and this is going to be a big factor, of course, in helping stand establishment.

Senator **Conrad**. One of the things that struck me is I was wondering do you get seed burn? I mean you are putting that fertilizer down with the seed, and there is a separation. Do you get any burn problem?

Dr. **Papendick**. There is a separation of about an inch from between the seed and the fertilizer, and it can be altered. We can alter that, but the way the original equipment has been designed, and we have experienced a slight decrease in emergence using the fertilizer urea, a slight decrease. But it had absolutely no effect on the yield because wheat crops—we tested on wheat and barley—they have a way to make up for any stand loss. We had a slight stand loss, but it was so insignificant, and it absolutely had no effect on yield. I would say this blanket statement that we have not experienced any problem with fertilizer burn from using this equipment.

Senator **Conrad**. All right.

Dr. **Baker**. Could I make an additional comment, Mr. Chairman?

Senator **Conrad**. Absolutely.

Dr. **Baker**. You mention the way in which the slot is made. I guess the most characteristic thing of the slot is that under the no-tillage system, there is an equilibrium relative humidity in soil right down to wilting point of 100 percent. Under tillage, the soil is so porous that we cannot use that humidity. In fact, it equilibrates at about 60 percent in most atmospheres.

But if you make the slot correctly, and I am talking about inverted-T shape, we can hold that 100 percent or very close to it (about 95 percent) for about 5 or 6 days postsowing. And that really is the key to the emergence from this particular slot.

All of the other slots encourage a loss of humidity at a greater rate than does the cross slot. The effect that that has is more on survival of subsurface seedings than it is on germination. It does have an effect on germination. You can germinate seeds at 100 percent humidity, but most importantly, as the seedling is under stress between germination and emergence, if it can be held in a cocoon of high humidity, it will survive there for up to 8 weeks. We have measured 8 weeks in the field. That really is the critical difference between no-till and tillage. There is not that humidity, even if you could make the right slot under a tilled system.

Senator **Conrad**. All right. I think that is a very important point to have made.

Next we will hear from Dr. James Parr, the coordinator of the Dry Land Agriculture Project of the Agricultural Research Service, USDA, Beltsville, Maryland. Welcome, Dr. Parr.

STATEMENT OF JAMES F. PARR, NATIONAL PROGRAM LEADER FOR DRYLAND AGRICULTURE AND SOIL FERTILITY, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE, BELTSVILLE, MD

Dr. **Parr**. Thank you, Senator. It is a pleasure to be here. I appreciate the opportunity to speak briefly about the importance of dryland agriculture, dryland or rain-fed agriculture, worldwide, as well in the United States, the need to develop more stable and productive and sustainable dryland cropping systems, and the need for new and innovative technologies for improved management and conservation of the natural resource base, namely our agricultural lands.

I am the national program leader for dryland agriculture and soil fertility, USDA. I also serve as the coordinator of the USDA/USAID dryland agricultural project that began in late 1983 because of the recognized urgency of directing U.S. expertise toward three geographic regions in the world where I spend most of my time to improve and increase production of food, food grain crops under conditions of limited rainfall. These areas are the Near East, Sub-Saharan Africa, and South Central Asia.

As I said, I was borrowed in 1983 by USAID and the most permanent thing in the world is something temporary, so I am still there. But I do coordinate the dryland projects in the United States and coordinate those with dryland agricultural systems in those regions. I call your attention to the fact that about 40 percent of the Earth's land area is in dryland or rain-fed cropping systems. These areas are inhabited by about 700 million people, and that population is growing. About 60 percent of the world's drylands are in developing countries where farmers produce, for example, 50 percent of the world's groundnuts or peanuts, 80 percent of the pearl millet, 90 percent of the chickpeas, and 95 percent of the pigeon peas, and most of the world's sorghum. These are basic food crops to these people.

These areas will continue to produce most of the world's food grains for their expanding populations. However, yields are very low, and in some countries such as in the Sub-Saharan zone of Africa, food grain production per capita has declined alarmingly during the past decade. Much of this can be attributed to the deterioration of the soil resource base from desertification, erosion, intensive cropping, and grazing. Consequently, there has been a loss of soil productivity.

The arid and semiarid regions—this is also true of the United States—are rather fragile ecosystems. They have limits, and we have to observe that there are limits in how we farm them. The principal constraints to increased agricultural production in these areas are insufficient and unpredictable rainfall and coarse-textured, sandy soils that are inherently low in fertility, low in soil organic matter, low in water-holding capacity and thus subject to a number of degradative processes such as wind and water erosion.

Certainly, the key to improving the productivity, stability, and sustainability of rainfed/dryland cropping systems is to halt any further deterioration of the natural resource base, namely, agricultural land. This can be achieved largely by the implementation of sound soil and water management practices. In many cases, improvements can be achieved by the application of established principles of soil and water management to crop and livestock production. In other situations, new concepts and methodologies such as what we are talking about here, may be appropriate to the unique aspects of dryland or rainfed systems.

An important feature of conservation farming is the proper and regular addition of organic residues, animal manures and so on, to that farming system. In conservation tillage systems much of the residue must be positioned on or near the soil surface for effective control of wind and water erosion and to reduce evaporation of soil water. As we have heard here today, a serious limitation to the success of the conservation tillage farming and no-till systems, or reduced till systems, has been the lack of appropriate technology, namely, drill openers, that would allow precision placement of seed and fertilizer at planting with minimum disturbance of the soil, without tucking of surface residues into the seed slot, and without excessive draft (or energy) requirements. We feel the new cross-slot technology fulfills all of these requirements. In addition, a special feature of the cross-slot opener is the effective closure of the seed/fertilizer slot, which prevents desiccation and conserves soil moisture.

So in conclusion, I would say that based on research conducted by USDA's Agricultural Research Service, and that which was conducted by Massey University and elsewhere, we feel that this new technology is a marked improvement over the standard and conventional openers, and has great promise for our U.S. farmers as they seek to develop productive, competitive, and environmentally-sound farming systems in the years ahead. It also could be a significant breakthrough for farmers in developing countries as they struggle to survive, to improve their standards of living, and to protect their very fragile resource base.

We also are encouraged by the fact that this technology can be adapted to animal traction, because in the countries I work in, you will not find many tractors. They do need this type of technology for better utilization of limited amounts of fertilizer and to increase the efficient use of whatever fertilizer they might apply, and also to conserve moisture in that particular situation. Thank you.

Senator CONRAD. Thank you very much.

[The prepared statement of Dr. Parr follows:]

STATEMENT OF DR. JAMES F. PARR, NATIONAL PROGRAM LEADER FOR DRYLAND AGRICULTURE AND SOIL FERTILITY, AGRICULTURAL RESEARCH SERVICE, UNITED STATES DEPARTMENT OF AGRICULTURE

Mr. Chairman, and Members of the Committee, I appreciate the opportunity to discuss the importance of dryland agriculture worldwide, the need to develop more stable, productive and sustainable dryland crop/livestock systems, and the need for new and innovative technologies for improved management and conservation of the natural resource base, i.e. agricultural lands.

I serve as Coordinator of the USDA/USAID Dryland Agriculture Project that began in late 1983 because of the recognized urgency of directing U.S. expertise toward three geographic regions where there is a critical need to increase the production of food grain crops under conditions of limited rainfall, i.e. the Near East, Sub-Saharan Africa and South Central Asia.

Approximately 40 percent of the world's land area is comprised of arid and semiarid lands that are inhabited by some 700 million people who are mostly farmers. About 60 percent of these drylands are in developing countries where farmers produce 50 percent of the world's groundnuts, 80 percent of the pearl millet, 90 percent of the chickpeas, and 95 percent of the pigeon peas. Although these areas will continue to be the major source of food grains for expanding populations in these countries, yields are generally low. In some countries of the Sub-Saharan Zone of Africa food grain production per capita has declined alarmingly during the past decade. Much of this can be attributed to deterioration of the soil resource base from desertification and erosion and the consequent loss of soil productivity.

The arid and semiarid regions are highly fragile ecosystems. The principal constraints to increased agricultural production are insufficient and unpredictable rainfall and coarse-textured, sandy soils that are inherently low in fertility, low in soil organic matter, low in water-holding capacity and thus subject to degradative processes such as wind and water erosion.

The key to improving the productivity, stability and sustainability of rainfed/dryland farming systems is to halt any further deterioration of the natural resource base, i.e. agricultural land. This can be achieved largely by the implementation of sound soil and water management practices. In many cases, improvements can be achieved by the application of established principles of soil and water management to crop and livestock production. In other situations, new concepts and methodologies appropriate to the unique aspects of dryland areas will be required.

An important feature of conservation farming is the proper and regular additions of organic materials such as crop residues. In conservation tillage systems much of the residue must be positioned on or near the soil surface for effective control of wind and water erosion and to reduce evaporation of soil water. A serious limitation to the success of conservation tillage and no-till systems has been the lack of appropriate technology, i.e. drill openers, that would allow precision placement of seed and fertilizer at planting with minimum disturbance of the soil, without "tucking" of surface residues into the seed slot, and without excessive draft (or energy) requirements. The new cross-slot technology fulfills all of these requirements. In addition, a special feature of the cross-slot opener is the effective closure of the seed/fertilizer slot which prevents dessication and conserves soil moisture.

Based on research conducted by USDA's Agricultural Research Service, we feel that this new technology is a marked improvement over the standard and conventional openers, and has great promise for our U.S. farmers as they seek to develop productive, competitive and environmentally-sound farming systems in the years ahead. It also could be a significant breakthrough for farmers in developing countries as they struggle to survive, to improve their standard of living, and to protect their very fragile resource base.

I'll try to answer any questions that you or other members of the committee may have.

Senator **Conrad**. Let me pursue with this panel, and maybe while we are starting this, the previous panel would come up and join us. Somebody can sit here, and I have three chairs there on the end. If you would join us, and we will just open this discussion up so that we have a chance to raise whatever points or questions people might have. I want to encourage any member of the panel to ask questions of any other member. We want to be as informal as possible and really have a discussion that is meaningful.

I must say I am very intrigued with the cross-slot opener. I really think it offers an alternative that deserves very strong research in this country, and I hope that adequate funding is available. It would be the first question I would ask. Is there adequate funding for research into what the cross-slot offers farmers not only in this country but other parts of the world?

Are we making a maximum effort to investigate this method?

Dr. Papendick, do you have sufficient resources to pursue this method?

Dr. **Papendick**. The truth of the matter is that the only location in the United States Agricultural Research Service, USDA, the only location in the USDA Agricultural Research Service that is conducting research on the cross-slot is at Pullman, Washington.

Senator **Conrad**. So we are not testing this methodology anywhere else in the country?

Dr. **Papendick**. Except through our location. Now this past winter it was tested in California. We only have one research machine. It is being tested now in California one season. Other than that and bits and pieces that Dr. Baker has had a chance in earlier years. There was some preliminary things Dr. Baker you may want to mention, but these did not go very far. So the dollars that are being spent on this research are very little of what we have had in our project, and we are not able to expand any further than we have been doing now.

Senator **Conrad**. Let me just ask you this. You have testified here today that you are very impressed by the opportunities, the potential that this system offers?

Dr. **Papendick**. Yes.

Senator **Conrad**. That it is unusual in terms of the results that you get, and based on that, it would seem to me that we ought to be in widespread testing across the country. Would you agree with that proposition?

Dr. **Papendick**. Exactly. I would agree with that, and that is what is desperately needed. And we have been looking into ways of how this can be accomplished, and hopefully that we will be able to get some things going that we can move it to other areas. For example, in your State, in Texas and in Colorado, Nebraska and then we have not had any testing done in the corn country. This is something that is not even gone into yet. And I think personally that, for example, I mentioned ridge till. Ridge till is growing in popularity in those States because it has a lot of advantages. It is a very effective conservation system.

I think this technology has great merit in enhancing the ridge till system of farming which is, as I say, growing because of the unique placement of the fertilizer and a seed on these ridges. It is difficult to do both simultaneously unless you have the specific equipment to do that. But let me just say this, too, that where we are really excited with this emphasis now is on low-input sustainable farming, there is more growing interest now in how we can use legumes, intercropping, cover crops and other kinds of things like this.

For example, now in Washington State, we are getting very interested in growing legumes on set-aside. For the first time now we have a technology. We have to have equipment to do this. I think now that with this technology, I think we are going to be able to move into that now and be able to do something that will be of benefit to the farm.

Previously, without the equipment we could not do it. We would talk about it as a nice concept, but we could not do anything about it.

Senator CONRAD. That is the bottom line.

Dr. PAPENDICK. It is opening the door.

Senator CONRAD. It is not going to be adopted. It is not going to be out there across America unless it helps the farmer produce. And the testimony that you are providing here today is this methodology improves dramatically the bottom line, improves the production; am I correct?

Dr. PAPENDICK. It improves production and environmental protection. It improves protection of the resource base. At Pullman this is one of our main objectives and that is how to prevent erosion, how to prevent groundwater pollution, and more healthier, stable farming systems. And I think this is a technology that should help us go a long way in that direction.

We are very optimistic and we are going to do all we can to study, to expand our knowledge about how it can be improved, and whatever it takes to obtain the maximum benefits.

Senator CONRAD. You know there have been some who have said, this is for the fruit and nuts crop. From the beards and beads people, this kind of agriculture. We are out here in American production agriculture. We have to make it work, and we are very vulnerable economically and we cannot afford to be diverted and go off on some of these methods that are for people who are weekend farmers. From your observation and your analysis, this does not fit that description at all?

Dr. PAPENDICK. Absolutely not. This is for U.S. agriculture. It is something that we are looking at for U.S. agriculture, varying degrees, varying sizes of farm production. In other words, it is not limited to the small scale. It is not limited to the large. It should cut across the whole diverse scale of farming operations absolutely. Just as we have seen on the film, it can be downscaled. You can make a huge machine of it, if you wish, so that is not a limiting thing.

But our interest there at Pullman has been adapting it to meet a number of conditions, just as I said, in cover crop seeding, the increased use of legumes, and to meet these sustainable objectives. We have to have the tools to do it. I think we have started to get our hands on something now that can carry us forward.

Senator CONRAD. Dr. Baker.

Dr. BAKER. I think it is important to reiterate separately what Dr. Papendick said in terms of the utilization of the technology from further development of the technicalities of it. That is an ongoing process. We have recently signed an agreement with a USA firm that effectively transfers the technology into this country from the university but links the university in as a continuing partner in this process.

We have a long-term program out there to build on this technology, further develop it, to take in the numerous smaller less dramatic, but nevertheless important technological problems that have to be solved in no-tillage to make it universally adopted. That will continue. The funding for that is, I guess, adequate for the moment, but by no means ever in surplus. But we see that as our responsibility, and we see the responsibility of Dr. Papendick and others in the USDA as extending that and feeding back. It is a three-way linkage between the company, the USDA and Massey University at this stage.

Senator CONRAD. Well, we really have a dual track. I mean in many ways this is ready to go into the field now.

Dr. BAKER. Yes, it is.

Senator CONRAD. Am I correct? I mean we are ready for implementation on the farm with methodology. We are talking about a dual track here of additional testing so that we learn more about how it works and what the applications are and what kind of results we can expect to achieve with various crops, various parts of the country, various soils, all of those questions that are important ones to answer as well. Am I correct?

Dr. BAKER. Yes, indeed.

Dr. PAPENDICK. How we can apply it to even more situations to capture even more benefits. We are going to get a lot of benefits, but there are even more than we do not even know about, I am sure. This is what we are excited about.

Senator CONRAD. We are talking about environmental benefits. We are talking about production benefits for farmers. We are talking about being able to deal most efficiently with whatever moisture conditions we confront. In my part of the country, that is critical. I mean there is nothing more important on an ongoing basis in my part of the country than being able to maximize the moisture that is there, but in the situation that we confront today, having come through the most severe drought in 50 years, it becomes even more serious.

Mr. Kinsella, you had a comment?

Mr. KINSELLA. I would like to respond to the planter as a corn farmer in Illinois. I think it has tremendous application. I have been no-tilling corn since 1975, and I have been frustrated with the fact that we do not, even after 15 years, have a good planter. I have talked to the major equipment manufacturers and what we have is really a conventional tool, which is the old disk opener. All that is is an extension of the runner for conventional tillage, to move the clods apart, to put the seed in clod-free ground, in work ground. It is a conventional tool, and for the first time we have something built from the ground up.

We have been in a bit of a paradox in that the people that are building the corn planters also make a lot of other equipment which is associated with tillage. So there has not been a big incentive for them to spend a lot of money to develop a no-till system that is really ideal for the crop, and I do see this as a tremendous boost to corn and soybean production in the Midwest as well as wheat, alfalfa, and corn production. You might have read that no-till has had some problems. I think over 60, maybe 70 percent of the problems I have seen this year is with side-wall compaction, which as a corn plant grows, as secondary roots come out, about an inch above the seed, they hit this compacted sidewall, and they cannot grow.

It is not so much an emergence problem, but you no-till your corn, and it does not look as good as your neighbors. It goes through a period of slow growth. So everybody assumes it is not good, and you get a lot of press articles. I see this as being able to avoid that side-wall compaction and to me a tremendous potential for corn production.

Dr. **Papendick**. This is a good point. Now we have essentially seen the same thing with wheat, where we have planted with double disk opener and with the cross-slot opener. The early stages of wheat with the cross-slot planting appears to yield much more vigorous, healthier plants, but we cannot explain why. We do not have the answers, but I am listening to what you are saying. And somehow that early seed environment is somehow improved so that these plants can come up quicker. And, as I indicated, in this past year we have about a 15 percent yield increase which I think we have to give credit to the better stands, the early stand establishment, and more vigorous plants.

Senator **Conrad**. Let me ask this if I can pursue this question. In my State, we have a lot of use of hoe openers. Have you done any comparison of hoe openers to this methodology?

Dr. **Baker**. Can I answer that?

Senator **Conrad**. Yes, Dr. Baker, go ahead.

Dr. **Baker**. The big difference, and I think the single biggest mistake that researchers the world over have made is to extrapolate from tilled soils to untilled soils with the simple assumption that all you needed was more weight and more robustness. What in fact you have in a tilled soil is that you create an environment which is quite separate from the growing environment alongside.

The soil alongside is undisturbed. The slot zone is disturbed to some degree. There is an interface between that disturbed zone and the undisturbed zone which does not exist in a tilled soil. As the seed germinates the roots attempt to establish themselves in the untilled soil, not in the slot zone. To do this they have to negotiate that interface. That is the time when they are most under stress. In the compacted side walls of a V-shaped, double disk opener, that stress becomes, in fact, quite chaotic for the plant particularly if it is under moisture stress at the same time.

If you shatter that wall, as with a hoe type of opener, for example, or a cross-slot opener, the negotiation of that interface becomes simpler. The hoe type opener has the single disadvantage that it disturbs such a wide zone of soil above the slot that it does not trap the high moisture vapor.

It has physically the correct characteristics in terms of the root, the beneath seed-zone, if you like. It has physically the wrong characteristics above the seed. What the cross-slot does in effect is takes the physical attributes of the hoe opener beneath the seed and combines those with a closed off top system to give you the best of both worlds, both above and below the seed.

One of the things that seeds can do physiologically as they germinate is to direct their reserves to whichever part of the plant that has the most stress. And if the roots have the most stress, they will send their reserves down there. That reduces the amount of potential for shoot growth and vice versa. So the whole slot shape, whether double disk or cross slot is inexplicably bound up with the ability of the seed to germinate in one environment and grow in another and to negotiate the interface in between without stress.

Senator **Conrad**. Let me go back. If a North Dakota farmer were sitting here, and Duayne, you know this well. If a North Dakota farmer were sitting here the thing that would be going through his mind over and over, and we have asked it before, but I think we should address it again. The question that would be going through his mind is what does this do to my bottom line? It is not just what happens on the cost side. It is the bottom line. What does this do to profits?

Has anybody done an analysis of that? I mean obviously production plays a role in that. Am I going to have increased production, reduced production, the same production, but the whole, the whole dynamic from the farmer's point of view is what does it do to my bottom line? What does it do to production? What does it do to my costs? Duayne, do you want to comment on that?

Mr. **Baldwin**. Well, I guess I would like to know for the farmers in North Dakota, what adaptability? Would you have to buy a complete unit or could you convert existing units? We have existing air delivery systems on air seeding. Concord is one of them that does have a delivery system. Could these be adapted to an existing unit or would you have to go with a complete drill? Dr. Baker.

Senator **Conrad**. Dr. Baker.

Dr. **Baker**. In the main, you will have to go with a complete drill. The opener requires a preset angle of about 4 degrees to the horizontal, and it is important to maintain that wing angle. That dictates parallelogram drag-arms which are not usually available on air seeders, for example. The space requirements and the depth control requirements dictate really that the drill is designed around the opener. We do not favor fitting openers retro to existing drills because the opener in the end tends to suffer from the inadequacies of the drill design in the first place.

Senator **Conrad**. Let me go, if I might, to Mr. Kinsella, if you want.

Mr. **Kinsella**. I am also a farmer in Illinois and to me the bottom line has been affected. I have been no-tilling, and that seems to be the misunderstood part of converting to no-till. Most people think you are going to lose money. I am convinced I have been more efficient in our farming operation. I went about last year to develop a computer program so a farmer could analyze his situation right now, by comparing what he is doing versus a no-till system. And I will share this with the subcommittee. It is available now through the 12 States across the Midwest, from Ohio through the Dakotas. And it is a simple form that a farmer fills out as to what he is doing now.

It includes all his input costs like herbicides, seed, and his trip costs, as well as his projections on herbicide costs for the no-till system. What most farmers do not understand is what it costs them to go over the farm four or five to eight times in tilling. With all the equipment they have, there is not a good understanding of what tillage actually costs, until they get rid of the equipment. And that is the big difference on the bottom line. You are going to be more efficient as a no-till farmer in just about every case as compared to a conventional farmer.

[The information of Mr. Kinsella can be found on pages 34 to 36.]

Senator CONRAD. Dr. Papendick, do you want to comment on this question of what it means to farmers from your observation? You have been engaged in this——

Dr. PAPENDICK. I am not clear on your question entirely, and that is are you making comparisons with something?

Senator CONRAD. Yes.

Dr. PAPENDICK. Compared with?

Senator CONRAD. Compared with traditional method.

Dr. PAPENDICK. Traditional or other types of equipment.

Senator CONRAD. Right.

Dr. PAPENDICK. Well, I am not going to—those kinds of analyses we really have not carried out. But let me give you just two experiences that we have had. And your earlier question was, have we made comparisons between this cross-slot, the cross-slot opener and other openers like the hoe opener? Let me give you two instances of our experiences.

And as I say, we are a small research unit. So we can only carry out so much research. In 1987, Dr. Saxton had a comparison with a hoe type opener on Spring wheat. The cross-slot versus hoe for Spring wheat no-till seeding in Winter wheat stubble. The hoe type opener, fertilizer placed under the seed, yielded 49 bushels an acre. The cross-slot right beside it in an experiment replicated four times, 63 bushels an acre. In addition, last year——

Senator CONRAD. Let me make sure I have these numbers correct in my head. You did an analysis. Dr. Saxton, as I understand it?

Dr. PAPENDICK. Yes, he was the——

Senator CONRAD. Hoe opener versus cross-slot opener.

Dr. PAPENDICK. One experiment so we can take it that far.

Senator CONRAD. All right. But four replications on the cross-slot.

Dr. PAPENDICK. All of them. I mean this experiment was replicated so——

Senator CONRAD. Four times?

Dr. PAPENDICK. Right.

Senator CONRAD. And on hoe opener you got 49 bushels to the acre.

Dr. PAPENDICK. That is right.

Senator CONRAD. On the cross-slot you got 63 bushels to the acre.

Dr. PAPENDICK. Or 62, something like that. So there was substantial gain with that. Secondly, and this is not a comparison, but last year—was it last year, Keith, or the year before?

Dr. SAXTON. Last year.

Dr. PAPENDICK. Last year a farmer or a number of farmers used a hoe type opener to seed about three-quarters of a million acres of Spring wheat in the dryland area near Ritzville, Washington, and lost it all, with a hoe opener, placing the fertilizer under the seed. Some marginal moisture conditions and probably complicated with fertilizer burn, lost it all, a practice that they will not do anymore. So we have to find something better. This was in no-till. So that practice is wiped because now how are we going to get these farmers encouraged to go back into no-till again. They are going to blame no-till for this.

Senator CONRAD. Yes. Ralph, you had a comment?

Mr. GROSSI. Well, a related comment. I agree with your supposition that profit, bottom line is the driving force of the farmer. One of the things that affects that bottom line, though, is ability to remain in compliance with the Federal farm programs, at least under existing programs, and that is another force that farmers are looking at over the next 5, 6, 7 years in terms of meeting those compliance requirements. New technologies are going to be important to do that. In our surveys, we have found that farmers have a great deal of confidence in the research system, the land-grant system and the extension system, in terms of confidence in the reliability of the data that comes out. It is very high. It is the highest.

However, what we have also found is that their sources of data are other farmers and salesmen predominantly. And the university extension system tends to rank quite low in source of data. High on confidence but very low on source. So if they are not getting the information from the high confidence source, there is a problem here. Might I suggest that strong consideration be given to the kind of research that farmers accept, that is from other farmers and on-farm research.

I am getting back to the new low-input sustainable ag program. There were 53 farms in four regions of the country this year funded for those projects in cooperation with universities and other organizations. There will be another 50 to 60 funded in 1989. We have over 100 farms in four different regions of the country overviewed by technical advisory committees.

It seems like the proper arena in which to move this research, get it out on the farm, find out within these regions what can happen. Of course, it all depends on the funding for those regional programs, but that seems like a quick way to move adoption of technology. You know, adoption of new technology in agriculture runs varying spectrums. Sometimes it is very rapidly adopted and when you have pressures like compliance on top of normal profit and loss pressures, then you have an opportunity to move new technology into the farm community very rapidly. I am suggesting that the LISA program is a way of accelerating that adoption.

Senator CONRAD. Let me ask a question that Senator Kerrey, which is in line with what you have just said. Senator Kerrey left this question with me. In USDA testimony at the Appropriations Committee—Senator Kerrey serves on the Appropriations Committee—they said that the $175 million is being spent on low-income sustainable agriculture. This was their justification for cutting the sustainable budget. He wanted to ask these panels if you share that attitude? So I would throw that out. Ralph, you might want to respond.

Mr. GROSSI. Do I share the attitude that the existing infrastructure doing low-input sustainable ag serve the need? Not entirely.

Just because of what I said earlier in my testimony and just now. First, the on-farm research tends to be more readily adopted and accepted by farmers even though the reliability might not be as high in the first year or two. Secondly, the LISA program, which has been funded now for 2 years, provides a mechanism by which there is a two-way information exchange, and the existing structure does not lend itself to a two-way information exchange.

Senator CONRAD. OK. Any other comments, final comments? Yes, Duayne.

Mr. BALDWIN. I guess I have one on the incentive for no-till farming. We have talked about back in North Dakota as far as giving an incentive per bushel per acre or something to a farmer that did no-till instead of paying someone to take this poorer land out of production. And some day we are going to need the production. And that is one of the thoughts. I guess maybe it was 10 cents or 20 cents a bushel or something like this instead of going to a price support program as such. But there has got to be a way to get an incentive instead of rewarding the guys that have been doing everything wrong, and paying them to take that land that they have abused out of production, which is rewarding the wrong people for the wrong things, I feel.

Senator CONRAD. All right. Any other last comments?

Mr. KINSELLA. I would like to comment just one more time on earthworms. They are very important to no-till. I think every no-till farmer tells you that, but conventional farmers look at you like you are kind of weird if you start talking about earthworms. Of course, they are underground. People do not appreciate them really, and they are important.

Senator CONRAD. The under-appreciated earthworm.

Mr. KINSELLA. The under-appreciated earthworm. So if you are a no-till farmer and you do not have them (they actually are not native to the United States), I think you need to get some. I think there needs to be more research emphasis on the development of the earthworm, because they are so beneficial. As an example of some work that some innovative farmers are doing, I will present you with some earthworm cocoons here, a new method of seeding earthworms to the soil.

Because if you look at the impact of say 330 miles of holes, in an acre, the size of a pencil, that has one heck of an impact. Bill Edwards has found that you can grow corn on a 15 percent slope without erosion, and the reason is earthworms. So maybe we ought to start to looking at ways we can get them started. An innovative farmer has figured out the way to harvest cocoons. They do not survive very well. They put them in capsules, and then they are actually planting them with soybeans. They have determined in New Zealand that maybe only about 250 per acre one time is all you need to get them started.

I think we need additional research in this field; better species, more adapted maybe to drylands, some basic work like that, and then to perfect the technique of planting them. It could be a real boom to agriculture in the next years.

Senator CONRAD. Great. All right. Thank you very much. Again, I want to thank both panels. You have been terrific. I think we have received very good testimony here this morning. Some very exciting concepts out on the table, and I am excited by this. I think this is exactly the direction we need to be going, and I want to thank you all for the work that you have put into this.

[Whereupon, at 11:05 am., the subcommittee adjourned, subject to the call of the Chair.]

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